REPORT RESUMES

ED 013 762 SE 002 773

THE 1957 UNIVERSITY OF UTAH RESEARCH CONFERENCE ON THE IDENTIFICATION OF CREATIVE SCIENTIFIC TALENT (2D, BRIGHTON, UTAH, AUGUST 17-20, 1957).

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PUB DATE 58

EDRS PRICE MF-$1.00 HC-$10.72 268P.

DESCRIPTORS- *CREATIVITY, *CONFERENCE REPORTS, *LEARNING THEORIES, *RESEARCH REVIEWS (PUBLICATIONS), *SCIENTIFIC MANPOWER, *SCIENCE EDUCATION, ABILITY, CULTURAL FACTORS, ENGINEERING, INTELLIGENCE FACTORS, INTERESTS, INTELLIGENCE, PROBLEM SOLVING, PERSONALITY, SCIENTISTS, VERBAL ABILITY, TALENT IDENTIFICATION, UNIVERSITY OF UTAH, NATIONAL SCIENCE FOUNDATION, STANFORD UNIVERSITY, OFFICE OF NAVAL RESEARCH, CONCEPT MASTERY TEST,

PAPERS PRESENTED AT A 1957 CONFERENCE ON THE IDENTIFICATION OF CREATIVE SCIENTIFIC TALENT ARE INCLUDED IN THIS REPORT. RESEARCH STUDIES AND POSITION PAPERS DEAL WITH THE NATURE, MEASUREMENT, AND ENCOURAGEMENT OF SCIENTIFIC CREATIVITY. STUDIES THAT EXPLORE THE RELATIONSHIP BETWEEN (1) UNDERGRADUATE GRADES AND RESEARCH ABILITY, (2) COMMUNICATIONS SKILLS AND CREATIVE ABILITY, AND (3) PERSONALITY AND ABILITY CHARACTERISTICS AND PRODUCTIVE SCIENTIFIC WORK ARE REPORTED. FACTORS THAT COMPOSE THE "STRUCTURE OF INTELLECT" AND THE DEVELOPMENT AND APPLICATION OF INSTRUMENTS FOR THEIR MEASUREMENT ARE DISCUSSED. CONDITIONS CONDUCIVE TO CREATIVE PRODUCTIVITY THAT EXIST IN GRADUATE SCIENCE PROGRAMS AND SOCIAL, CULTURAL, AND EDUCATIONAL FACTORS THAT INHIBIT CREATIVITY ARE USED TO ILLUSTRATE THE DEPENDENCE OF CREATIVE ACTIVITY ON ENVIRONMENTAL FACTORS. OTHER PAPERS CONSIDER THE ORIGIN AND DEVELOPMENT OF INTERESTS, THE MEASUREMENT OF PROBLEM-SOLVING ABILITY, PRIMARY AND SECONDARY CREATIVITY, AND TEACHING PROCEDURES THAT ENCOURAGE CREATIVITY. SEVERAL COMMITTEE REPORTS AND AN EXTENSIVE BIBLIOGRAPHY ARE INCLUDED. THIS DOCUMENT IS ALSO AVAILABLE FROM THE UNIVERSITY OF UTAH PRESS, BUILDING 303, SALT LAKE CITY, UTAH 84112. (AG)

ED013762

4-446 4-447
4-448 4-449: 4-450

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The Second (1957)

UNIVERSITY OF UTAH

Research Conference on the Identification of Creative Scientific Talent

CALVIN W. TAYLOR
Principal Investigator

(Supply limited)

Financial support was furnished by the National Science Foundation

Held at
Alpine Rose Lodge, Brighton, Utah
August 17-20, 1957

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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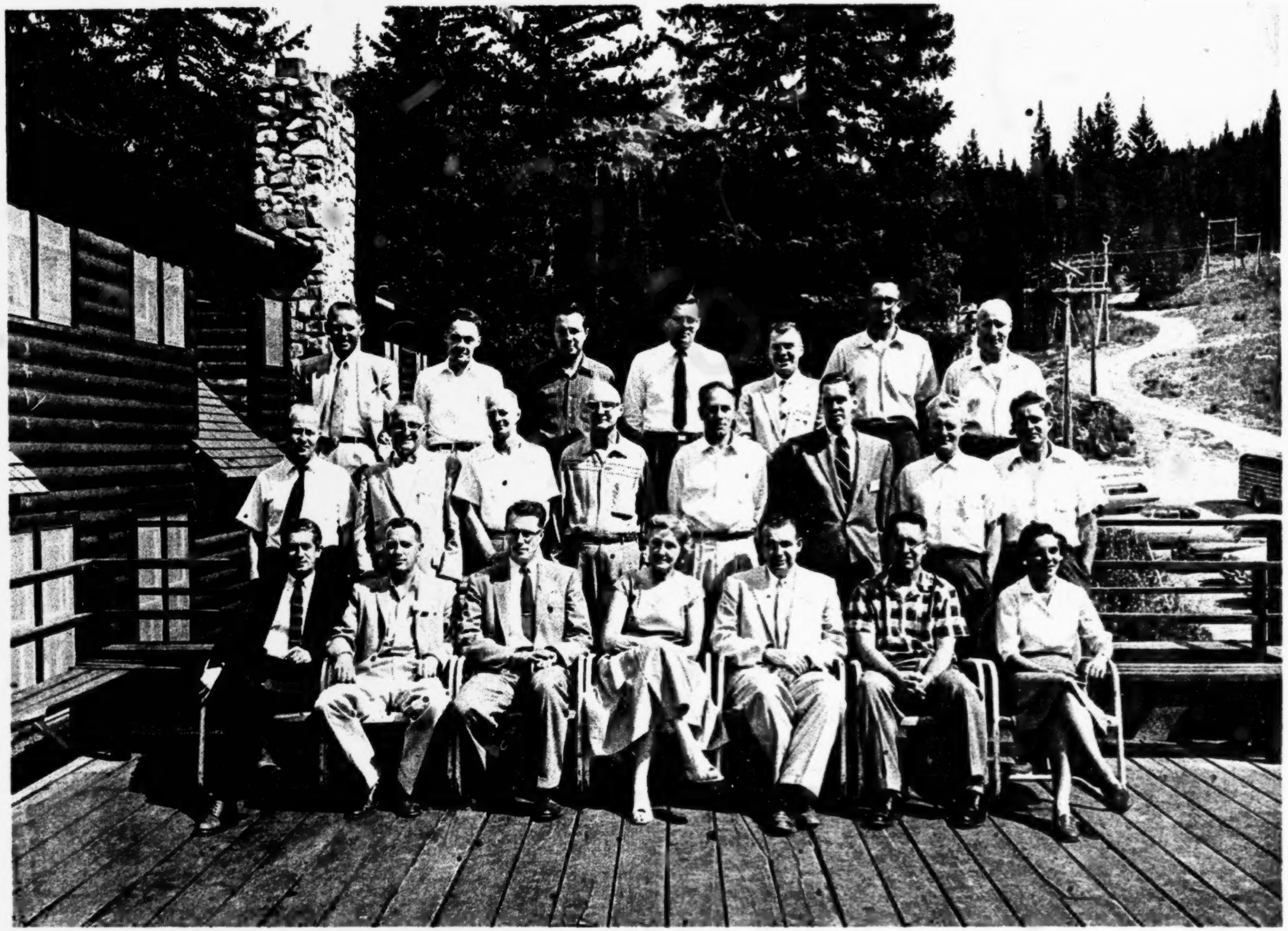

Front row, L to R: Bloom, Barron, Howell, Roe, D. Taylor, C. Taylor, Locke.
Second row, L to R: Smith, Allen, Owens, Guilford, Ghiselin, Rodgers, Mooney, McMurrin.
Back row, L to R: Mullins, Harmon, Lacklen, Holland, Murphy, Hills, Flanagan.
Missing when picture was taken: Olpin, Eyring, Crawley.

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PREFACE

This conference served as a follow-up of the 1955 conference as one important part of a long-range attack on the difficult problem of the nature and identification of creative scientific talent. The encouragement and financial support again provided by the National Science Foundation were essential to the staging of the conference. Bowen Dees was the key contact within NSF during the entire history of the conference. The importance of the framework provided by the administration of the University of Utah, developed mainly by President Olpin and Dean Eyring, which permits, encourages, and facilitates research activities such as this conference, is also acknowledged.

The participants were again selected on a national basis in terms of their work and contributions to the conference topic. A small number of participants were scientists outside of psychology, invited not only to give reports but also to react to the research findings by psychologists to date. One major change in the structuring of this second conference was that additional persons were invited to the conference who presented no report but who did enter into the discussion on the reports of others. Most of them also joined in the discussion and preparation of the subgroup reports. The additional persons present throughout the conference were John Holland of the National Merit Scholarship Corporation, Barton Howell of the Sperry Rand Corporation, Robert Lacklen of the National Advisory Committee for Aeronautics, Mary Locke of the National Science Foundation, Cecil Mullins of the Personnel Laboratory of the Air Force, and William R. Smith of the University of Utah. Other persons who participated in some of the sessions were Captain Walter F. Murphy of the U. S. Air Force, and S. L. Crawley and Sterling M. McMurrin of the University of Utah. Helen Marshall, who has been a key worker on Terman's gifted child project at crucial times throughout the history of the project and who reported on that project in the first conference, was out of the state and unable to attend the second conference. She permitted me to announce that she had been offered the position of Curator on the Gifted Child Project at Stanford University when she retires from the University of Utah.

There was considerable motivation among the participants toward gaining an understanding of the fundamental nature of creative scientific talent, with the conviction that sound, practical applications such as the identification, encouragement, development, and maximum utilization of this type of talent in an optimal environment can more readily flow from such increased understandings. This sustained interest and research effort related to creativity, along with their reports and discussions, formed the crux of the conference.

The setting for the second conference was very similar to that for the first one. The same beautiful isolated spot was chosen for its location. The steering committee of J. P. Guilford, Anne Roe, and Donald W. Taylor deserve a great deal of credit for their efforts in the selection of participants and in the formulation and staging of the conference.

The last full day of the conference was spent primarily in subgroup discussions, separately on the three topics of predictors of creativity, criteria of creativity, and conditions affecting creativity, the last topic arising through the interest of the participants. The first two subgroup reports are included at the end of the conference report. The leaders of the third subgroup on conditions influencing creativity felt that although their subgroup reported on the noticeable progress made in the limited time available, they had been unable to cover this relatively unexplored subtopic systematically and adequately enough to make a formal written report.

During the last few minutes of the conference, the participants mentioned any other completed or current research related to creativity that had not been explicitly mentioned. For example, the large, cooperative study under White House sponsorship on "Survey of Attitudes of Scientists and Engineers in Government and Industry" was described in some detail. This report has now been completed and is available through the U. S. Government Printing Office.

In accordance with a request made at the 1955 conference, the Educational Testing Service has made arrangements for an information exchange for research on creativity. The value of such facilities depends upon the cooperation of researchers in submitting material. The procedure calls for research workers in this area to outline their work as major phases of studies are completed. The outline should then be forwarded to ETS, where it will be reproduced and circulated among others in the field within a few weeks. Outline forms containing some suggestions of information which might be desirable to circulate can be obtained from Samuel Messick of ETS's Research Division. It is hoped that the exchange will be used to full advantage.

The process of preparing the final manuscript was essentially the same as used for the first report, the text being taken again from the tape recordings. After the initial transcripts had been carefully typed, the entire conference was audited in an attempt to correct and complete the transcription wherever possible. Each participant was sent his transcribed paper plus the discussion pertaining to it, which he then edited and returned. The essence of the discussion was retained because of the belief that every idea expressed should also be made available to all interested persons not in attendance.

Within each report the person talking is again identified only by S, C, or Q for the same reasons given in the 1955 conference report. These three symbols are defined as follows:

S--The speaker who is giving the report is doing the talking in this and in succeeding paragraphs until a different symbol appears at the beginning of a new paragraph.

C--A participant, otherwise unidentified except that he is not the present speaker, is making a comment.

Q--A participant, otherwise unidentified except that he is not the present speaker, is raising a question or making a statement which requires an answer.

Because of the method of reproduction, it was also necessary to adopt the stylistic procedure of giving sufficient information about a reference in the body of the report to identify it uniquely.

Since all of the NSF funds were expended for the travel and lodge expenses of participants, for recording equipment, and for transcription and typing work, some Army reserve credit was given for my work on the final report under a project (TAGO-2) in the 6500 R & D unit at Ft. Douglas, Utah, with the approval of The Adjutant General's Office.

The role and assistance of many persons, in addition to the steering committee and participants, in the formation and operation of the conference is gladly acknowledged. Mentioning some of these specifically, Hazel Myers played the strongest role locally in helping to formulate the correspondence and announcements and otherwise to set the stage for the conference. Joyce Stillman was the key assistant throughout the history of the conference and spent more time by far than anyone else on it. She painstakingly transcribed the entire proceedings from the tape recordings, performed editorial work, retyped revisions, and added a considerable amount of perfection to the total manuscript and to its final reproduction. Keith Hansen, Roy Johnson, Robert E. Jones, and Jack Woolaver very capably handled the recording of the conference, helped in many other ways during the conference, and assisted in some of the research mentioned in my own report. M. Duane Bown and William R. Smith also provided valuable assistance in the preparation and operation of the conference, the latter being the key research assistant in both the communication and the productivity projects covered in my report. I also want to acknowledge the invaluable encouragement from my wife throughout the project.

It is hoped that the exchanges at the conference together with the total report will stimulate more and better research, will accelerate the current research efforts, and will draw more attention to needed research in the area. In my opinion the appearance of the Sputniks unequivocally showed both the advisability of expanded efforts on this topic and the fact that the efforts had started none too soon. Already many handles have been found for initially taking hold of some part of the difficult area; some controversial issues have begun to emerge sharply; some of the leads are appearing to lose their previously expected value; other leads are evolving which appear more promising; and in general some real scratches are being made through the surface of this complex and vital problem. Not only is it felt that the research work of the participants and the two conferences were very timely, but it is also believed that the conference topic underlies science and its progress, because the crucial movement of the frontiers of science is essentially a human enterprise and like all other important human enterprises, too little is currently understood. Not nearly enough scientific research has yet been accomplished on such human enterprises to bring about the sound basis of understanding that is sorely needed.

Any shortcomings in the conference proper and in the total report are solely my responsibility. The imperfections in the report indicate that I was unable to bring the material to a higher level of accuracy and completeness with the time and facilities available. It has been a distinct pleasure to have worked and associated with all those in any way connected with the project.

August 27, 1958 Calvin W. Taylor

GREETINGS TO PARTICIPANTS

President A. Ray Olpin
University of Utah

S--It is a very pleasant experience for me to meet with you again. I recognize a number of you who were here in 1955. Although you made a good start then, we recognize that many years may be required before we should expect even a partial solution to this complex and vital problem.

We in the educational administration field become more concerned with the passing of each day over methods of identifying persons with creative talents and of helping them to develop and use wisely and effectively their abilities. Unless or until we can segregate those with potentialities for becoming research scientists from those whose forte seems to be in the fields of craftsmanship, we may find that those in the former category are enticed away from their schooling at an early age to engage in semiskilled work in processing operations. Especially is this a problem in states like Utah where industries are springing up on all sides.

The universities and colleges of the country are today faced with a dilemma. They recognize the shortage of top-flight scientists and their responsibility to train people to become leaders in the field of research. At the same time they are under pressure to shorten the period of training and to give a vocational slant to their offerings to provide a sufficient number of technologists or semiskilled craftsmen to serve the industrial or manufacturing plants. This dilemma can be met satisfactorily only by sifting the brilliant from the mediocre, by early identification of those who have creative ideas.

To illustrate the predicament in which we find ourselves today, I cite two editorials in the morning newspaper, one immediately below the other. The first is entitled "Fulton Started It," and continues, "It is one hundred fifty years ago today that Robert Fulton chugged to fame on a run up the Hudson River in the Clermont." He was cited as an individual of creative ideas, willing to take a chance, an inventor. The second editorial mentioned a problem which was brought up in the last State Economic Development Conference. It commented that the shortage of workers in the "in-between category" is more acute currently than that in engineering or in the field of common labor, and the editor here cries for more people of high-school age to be shunted into vocational training.

My footnote to these editorials is simply this: Let us not categorize young people arbitrarily. We need to conserve those with creative impulses to develop opportunities for the tradesmen. The importance of this is apparent when we take into account some figures presented at this same conference by the former assistant secretary of labor, now the special assistant to the President of the United States, which predict that by 1965 this country will produce 560 billion dollars' worth of goods and services. This production estimate was made contingent upon the existence of a labor force of 74 million people. Charts were presented showing that in 1930, with 46 million people employed, this country was able to produce $3,620 worth of goods and other products per year per worker and that over the succeeding twenty-five years the output per worker increased at about 2.8 per cent per year, to nearly $7,600 per year per worker. This increase is directly attributable to the work of creative scientists and engineers rather than to that of operating craftsmen. The semiskilled employee has actually worked less and produced more. Our national economy is thus tied up with the availability of leaders in the field of science, and we must do everything possible to encourage young people with creative talent to start at an early age to develop this important resource.

The necessity of identifying at an early age young people with creative talent takes on new significance because we are faced with the fact that there is an absolute decline in the number of people in the twenty-five to thirty-four year age group due to the low birth rate of the depression years. More inventions and creative ideas are given to the world by individuals in this age bracket than in any other. Because of this shortage of young people we must take steps to insure that a higher percentage of those with promise in the field of creativity are encouraged to use these talents to the maximum. Otherwise we may have difficulty in maintaining the economy of our country, let alone in expanding it.

This conference, therefore, rates as one of the most important, in my estimation. We at the University are happy to sponsor it, and we appreciate the financial assistance given by the National Science Foundation. We hope this support will continue until we have discovered more and more effective means of distinguishing between the talents of those suited for scientific work and those suited for vocational pursuits. Nobody knows better than those of us in educational administration how important it is to find ways of identifying creative talent while people are still young.

- studies

SOME VARIABLES FUNCTIONING IN PRODUCTIVITY AND CREATIVITY

Calvin W. Taylor
University of Utah

S--In this conference we are interested in the fundamental nature of creative scientific talent so we can learn how to measure and identify it. After we understand its fundamental nature and how to identify it, other things will flow more easily, such as how to develop and encourage creativity and how to establish an optimum environment for it. The first step is to learn all we can about its nature and then we can more readily build measures to identify it. It should be pointed out that we are interested in creative talent in all fields. The initial emphasis here, however, will be on creative talent in science -- and perhaps we will find that more of the initial studies have been performed on physical scientists than on biological or social scientists.

If one examines the current national picture in science he will find that a few billion dollars is being spent each year for scientific research and development, not including the additional amounts expended for the education and development of a next generation of scientists. From my viewpoint the crucial thing in the entire scientific research movement is, without question, the scientist. When a representative of a large organization recently indicated to me that his organization was especially interested in basic science, I promptly asked, "What is more basic in science than the scientist?" This illustrates my strong conviction that it is the scientist, first and foremost, upon whom we depend to push forward the frontiers of his science. To obtain the fruits of scientific research, we are dependent in every instance upon scientists. Even when money is being spent on research facilities, it can be said that the scientist is being surrounded with these facilities in an attempt to increase his chances of being fruitful.

During an interview this summer with a scientist at an Air Force laboratory, I obtained his graphical idea of the relation between the degree of scientific ability and the amount of facilities needed to solve a scientific problem of a given level of difficulty. The gist of his proposed relation is that the higher the degree of ability, the fewer the facilities a person will need to solve a given problem, or stated conversely, the lower the degree of ability the more facilities a person will need to solve the problem. If the ability is below a certain level, no matter what facilities are made available, the person will be unable to obtain a solution on his own.

It seems obvious that the same person can do better research with needed facilities than without facilities. One of the critical characteristics we may be seeking in spotting real pioneers in science may be the ingenuity and the ability to create or generate needed research facilities that are not already available. It may be that the person with higher scientific ability is also the person who can somehow stir up the additional facilities that he needs in order to cope with his particular problem at hand.

On this point Dr. Conant's ideas come to mind where he said he had learned that ten second-rate men are no substitute for one first-class man. He even stated further that it is useless to place second-rate men on a first-rate problem even if you are under pressure for a solution, because second-rate men often do more harm than good on such a problem.

In this report on some variables functioning in productivity and creativity, four different studies will be mentioned: one of undergraduate grades as predictors of research ability, a second on analogies between the measurement of communication and creative abilities, a third on creative thinking as inferred from troubleshooting behavior on electronic equipment, and a fourth on personality and ability characteristics in productive scientific work. The last three were supported by the United States Air Force.[1]

Undergraduate grades as predictors of research ability

I have been fortunate to be granted permission to report the first study. The organization that accomplished this study wants the information to be released but prefers to remain anonymous. Their report will be followed closely except for abbreviating it in a few places. My only role in this study is to present the following report on undergraduate grades.

With the increased emphasis on research, one of the most vital personnel problems facing the nation today is the identification and selection of students who have the aptitude to become research scientists. This is a common problem to government, industry, and the universities. The number of individuals with outstanding research ability is inadequate at best. Appropriate techniques must be evolved to identify those with high research potential and to assure that a very sizable percentage becomes properly trained and then pursues work in essential research areas.

One measure of research aptitude being used by organizations is the grade point average of college students in undergraduate courses. Previous research has found that undergraduate grades show significant correlation with graduate grades. However, there is very little statistical evidence -- and what is available is controversial -- to show a significant positive relationship of undergraduate grades to success as a research scientist.

This study is an attempt to find out how undergraduate grades relate to the overall professional competence of a group of research scientists employed in an organization whose mission is basic research in a specialized engineering field.

The sample for the study was taken from an engineering research center. Normally only those from the top 25% of a graduating class are considered for employment at these research centers. However, during World War II the shortage of scientifically trained personnel was so acute that large numbers were recruited without regard to their college grades as long as they met minimum qualifications of an undergraduate engineering degree. This allowed for a wider distribution of college grade point averages among the group studied.

For purposes other than this study, a careful analysis has just been made of the level and kind of research being performed by each scientist in the research center, so that all scientific positions have been categorized by difficulty level. The third and fourth levels of difficulty were used for the sample. The levels were characteristically occupied by full-fledged scientists below the supervisory level and well above the trained level. The third level of difficulty generally includes scientists who, working alone or with a few others, complete all phases of a research project including writing the research report. The fourth level included scientists on the more difficult projects usually working as a leader of a group of scientists.

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[1] Contracts AF 18(600)-1211, 41(657)-100, and 41(657)-158, the first two with AFPTRC and the last one now monitored by the Directorate of Laboratories, Wright Air Development Center, Personnel Laboratory, Lackland Air Force Base, Texas.

A total of 301 scientists was included in the original sample, thus defined. The 301 scientists made up the entire research scientist population in the third and fourth level at one large research center. Due to the unavailability of college transcripts and records, only 239 cases were used for analysis. All 239 persons held an undergraduate degree of one type or another in engineering. A comparison of the distribution of difficulty levels and efficiency ratings of those remaining in the sample and those dropped from the sample for lack of transcripts showed no significant differences.

Two measures were obtained on each of the subjects: first, a grade point average of undergraduate grades, and secondly, an efficiency rating on performance of research duties. All grades on the transcript were included when obtaining the grade point averages. A separate study showed that the grade point average for the technical courses alone was almost identical with the grade point average of the non-technical courses.

Since grading techniques differ from school to school, a system was devised to standardize the undergraduate grades on a five point scale from 0 to 4 with A = 4, B = 3, etc.; in terms of percentage grades, 94 - 100 = 4, 87 - 93 = 3, 78 - 86 = 2, 70 - 77 = 1, and below 70 = 0. The overall grade point averages were obtained by dividing the sum of the assigned values of the grades by the number of marks given. Each course was thus unit-weighted. A side study based on the same data indicated that averages weighted by hours credit did not change the individuals' overall grade point averages significantly.

Satisfactory performance of research duties was measured in accordance with a five category merit rating system. In this study no subjects were rated in the bottom two categories along the scale. This is to be expected since most of these cases were promoted to their present "journeyman" level from the lower grades, such promotions being primarily based on research ability. These merit ratings, although not the best, are considered a fairly reliable measure of performance on the job as research workers.

Table 1 shows the distribution of grade point averages, by merit rating subgroups for the total group of 239 subjects, and for a typical graduating engineering class from a selected university. The means for each category are also shown.

If a grade point average is to be predictive of future success as a research scientist, it would be expected that there would be fairly large differences in mean grade point averages of those rated in the "Top," "Second," and "Third" categories. As can be seen in Table 1, this is not the case. It can also be seen that the distributions of scores for the three rating categories are very similar and do not show staggered modes as would be expected if grade point averages were predictive. A triserial correlation was computed and found to be .06, as indicated in the table.

If college grades were predictive of research success, the grade point averages of the 239 successful scientists would be substantially higher than those of the engineering graduating class used as a control group. This difference was not found, as shown by

Table 1

Distribution of Grade Point Averages

Grade Point Average	Merit Rating of Performance on Research Duties			Total Subjects	A University Engineer Class
	Top	Second	Third		
3.80-3.99	1	-	-	1	1
3.60-3.79	2	2	2	6	-
3.40-3.59	8	4	2	14	5
3.20-3 29	7	9	4	20	13
3.00-3.19	5	9	4	18	16
2.80-2.99	13	13	5	31	24
2.60-2.79	4	26	5	35	24
2.40-2.59	13	20	8	41	29
2.20-2.39	8	16	5	29	30
2.00-2.19	11	9	3	23	14
1.80-1.99	4	5	3	12	-
1.60-1.79	-	5	1	6	-
1.40-1.59	-	3	-	3	-
Total	76	121	42	239	156
Mean	2.73	2.60	2.69	2.66	2.68
	Triserial Correlation = .06				

the mean of 2.66 and 2.68 for the two groups.

Although definitive conclusions applicable to all professional research groups and areas cannot be drawn from this study, it certainly puts a large question mark beside the use of undergraduate grades as a predictor of success as a research scientist. The shortage of research scientists is such a vital one today that recruiting should not be restricted on any basis which will exclude large numbers of potentially successfully scientists.

Within these research laboratories where the study was done, it was concluded that a large number of potential research scientists are being passed over by limiting recruiting to graduates with high grade point averages. The results of the study indicate that there was no relationship between grade point average and merit rating and that grade point average should be given preferably no weight in selecting engineers for this type of research.

Perhaps we will hear from later participants about other studies in which grades have been used to predict productivity or creativity. At least from this one study, a first hunch would be that in other fields of science, undergraduates' grades are probably also very poor or useless predictors of success in research laboratories. If this should prove to be true and if one prime objective in scientific education is to produce a new generation that will be productive in scientific research, then how lost we are in our current educational programs and in our measurement of the progress of students in science. One thing that must surely be tried is that the nature of the educational tasks must be modified somehow if we are to be able to predict research fruitfulness from the grades that measure the students' performances.

In my human engineering class I have attempted to change the nature of some of the classwork by requiring a term paper in which students must propose a new idea in the form of a new piece of equipment or a modification in current equipment that would make life easier for the persons who have to operate or otherwise live with the equipment. As a second, more radical attempt to change the nature of the task in a typical class, a new type of assignment for my personnel psychology students was tried last quarter. They were assigned to read articles pertaining to each chapter in the text and to use this literature as a springboard for new ideas of their own. For each article they were required to write a one-page report primarily on ideas of their own that arose from reading the article rather than on the content of the article. This was a new and difficult experience for nearly all of the students. They complained that they had never read so many articles for one class in their life -- in this attempt to get new ideas. One person even admitted that he got ideas in class and from other sources but then had a difficult time locating suitable literature articles to which he could attach the ideas for credit.

The question arises about various ways to score these reports. For example, I am curious about using a self-rating pertaining to the degree of naturalness or unnaturalness which each person felt as he attempted to accomplish this assignment of reading-for-ideas. It would obviously be easier to score their reports if a standard list of articles were to be read. Their ideas could then be scored according to quantity and quality, including uncommonness, such as Guilford has used. One wonders if a selected article should be used in this manner in preliminary examinations for graduate students. I strongly suspect that our current educational system does not generally encourage people either to read or to listen to get new ideas of their own, but emphasizes other response sets in these receiving-communication situations.

Analogies between the measurement of communication and creative abilities

The second study in this report is an analytical one of communication abilities supported by the Personnel Laboratory of the Air Force (represented here by Cecil Mullins). Three initial studies of communication abilities have stressed an analysis of the expressional abilities with most emphasis on written expression. The results of these analyses might be classified into Guilford's scheme of productive thinking of the divergent and convergent types. However, our customary communication abilities terminology will be used here instead.

We do not necessarily believe that we are always striking directly at productivity or creativity in science when constructing measures of expressional abilities. Nonetheless, it is felt that some of these abilities will be relevant and that some interesting analogies can be noted between the measurement of expressional productivity and the measurement of scientific productivity and creativity. In a particular field it is felt that somewhere among the productive will be found the creative. Certain expressional tests have been constructed and scores developed in an attempt to measure high quality and perhaps creative productivity. In other words, one goal in the studies of expressional productivity has been to separate quality of expression from quantity of expression. These attempts to sharpen the measurement tools are reported since they may have some relevance to the measurement of creativity.

Many landmark factors from previous studies of verbal abilities and from the factor studies of Thurstone, Guilford and others have been used. It is felt that several of these landmark factors should be validated against criteria of productivity and creativity in science since they appear to be relevant. Some of the traditional factors which should be validated are verbal knowledge, ideational fluency (which incidentally measures quantity of ideas -- not quality), associational fluency, originality, sensitivity to problems, spontaneous flexibility, and perhaps expressional fluency and adaptive flexibility.

At the 1955 Utah conference the Word Association test which measures associational fluency had indicated some promise for predicting success in science. Some additional insights have arisen about possible reasons why this is so. The Word Association test is a loose synonym test in the sense that the examinee is given a slightly-structured task of writing as many words as he can that are "somewhat like the given word in meaning." It measures the number of associations from the given word to other words that he judges to be somewhat like the given word in meaning. It is at least partly a measure of the number of loosely related associations in the subject plus his degree of uncritical-mindedness in allowing himself to write loosely-related words as appropriate responses. The emphasis is not on the production of words that are perfectly analogous in meaning to the given word, but on the production of any related word, however imperfect the analogy or similarity may be. In a sense, it is an awareness of some similarity amid differences in meanings. The more associations tied to a word and the more a person is willing to work at a crude level of analogy or similarity, the higher will be his score on the Word Association test. Since this test measures similarities even though imperfect, it may be a predictor of those who can readily find a first order, crude relationship operating in a complex scientific domain even though this relationship does not precisely fit all phenomena but merely shows a general relationship that is functioning. These persons who focus on any existing similarities may be contrasted with others who emphasize the more perfect fit down to the finest details of a relationship. The latter person tends to focus on all differences observed, with the intent of reducing the imperfect fit to a negligible degree. A present explanation is that the Word Association test measures the former ability of finding crude, first order relations, at least with verbal materials and perhaps also with scientific phenomena.

In many newly devised communication tests the tasks have been varied from the weaving together of many complex detailed ideas into a well-organized interesting story to the writing of a theme from a very slim lead. A variety of expression tests have also been used which involve the reduction of given materials such as extracting, outlining, abstracting, revising, telegram writing, etc.

Some of the recently discovered factors might be relevant to scientific work above and beyond the usual requirements of a scientist to communicate his findings. The various scores on the reduction-of-expression tasks did not hold together as a whole on one single factor nor are they yet very reliable measures. It is obvious that further work is needed in this area. However, the extracting of relevant ideas and the reduction of information from a large mass into a smaller compact summary both seem to strike at the core of many scientific activities. It is recognized that verbal descriptive materials and verbal expression are being utilized, but it is felt that these processes are at least analogous to the processes used by a scientist as he seeks to extract and summarize fundamental relations from a complex area of nature. He, of course, was not provided with possible answers from which to choose -- instead, he must produce his own answers.

One of the new factors was interpreted as "resistance to idea reduction" or alternately as "succinctness of expression." The scores with highest loadings on this factor are those in which the person does not sacrifice any ideas in order to obtain brevity of final expression even though the test instructions stress brevity of the final written responses. Instead, the high scoring person on this factor writes as briefly as he can with the strong self-imposed restriction to retain all the ideas in his original material. It would seem that persons scoring high on this factor would be those who would stress second-order corrections needed on first-order relations found in science.

Throughout the project multiple scores were attempted wherever possible so that there was an average of about two scores per test. Ofttimes a traditional and somewhat obvious quantity score was obtained and attempts were made to devise one or more quality scores above and beyond the quantity score. A general relationship about scoring was discovered that might be of interest. If the task was of moderately low level, it was possible to obtain two or more fairly separate scores, that is, a quantity and something else which is often a quality score in nature. On the other hand, if the task was of a very high level, attempts to get multiple scores usually failed; in such cases, most responses had to be of high quality to satisfy the minimum requirements of the task so that quantity and quality scores were extremely highly related -- in some cases correlating over .90. In this regard, the findings on a new Compounding Words test, which Brewster Ghiselin created, are pertinent. The examinee was given a key word such as "oyster" and he was to write new compound words that would be synonymous to "oyster." Appropriate responses were pillowfish and pearlchest. In an attempt to obtain five different scores from these essentially creative responses, it was found that the quantity-of-response score was very highly related to each of the four types of quality scores, namely originality, evocativeness, accuracy, and sound pattern. It may be of interest to know that in one study the Compounding Words test had one of the highest loadings on a factor that we tentatively called verbal originality.

Some findings with response sets should be mentioned since response sets may be very important in creativity and productivity. In addition to finding the traditional spontaneous flexibility factor, we found a new factor orthogonal to it interpreted as "broadly diffused attention." This factor is potentially valuable not only in communication but also in creative activities. A skimming test, for example, had the highest loading in this factor. Other tests with high loadings indicated that a person would obtain a good score by having a widely diffused set so that he would almost deal with the entire field of possible responses as a whole and would dip into any part of the area at any moment for a response.

Other response set differences appeared on a Word Story test. The person was presented with a list of unrelated words down the left hand margin of the page and asked to write a story using as many of these words as he could. Some persons apparently wrote with the intention of using all the given words as rapidly as possible; they usually obtained a high score on the number of words used, but a low score on coherence and interest of the finished story. Persons at the other extreme who attended primarily to expressing a well-organized story wrote more interestingly but weaved the given words into the story at a much slower rate and thereby obtained a lower score on the number of given words used.

Two tasks were developed which were slightly ambiguous in nature, each having a similar choice point. One was a Letter Star task and the other a Similes task, each allowing three responses per item. Since the instructions were not strongly structured but permitted a person to write one or more responses per item before going on to the next item, it was possible to obtain two scores for each task, namely, the total number of first responses and the total number of second plus third responses across the items. These scores were designed to separate persons who wrote first responses and then usually skipped to the next item, from other persons who tended to fill all the blanks on one item before going to the next item. We thought the latter would be a higher level score. On each of these tests the two types of scores had fairly low intercorrelations and appeared on somewhat different factors. Also, the second plus third response scores did not correlate highly across the two tests. For example, the total of the second plus third responses for the Letter Star test appeared with a main loading on naming facility whereas the same type of score on the Similes test fell on factors indicating low quality of responses, such as the factor interpreted as verbal superficiality.

At this stage it is not only believed that some of these response-set factors are important in creative tasks but it is concluded that semi-structured tests can be developed so that two or more different scores can be readily obtained which will separate persons according to their particular response sets.

One administrator in science strongly advised not to look for persons who are dilettantes when seeking scientists. The finding of a factor tentatively interpreted as verbal superficiality suggest that it is possible to devise tests that will separate people who deal with things on a very superficial level from those who delve more deeply into their area before committing themselves verbally. There is reason to doubt that the person who, in advance can clearly state his research problem, his expected outcome, and so forth, is necessarily the best prospect for scientific research work. These differences in ability to express oneself clearly in advance on a given problem may also be related to the motivation in undertaking theoretical or experimental research. It is possible that those who can readily give answers in advance, may as a group be less inclined and less likely to do further work on the problem in question than those who are somewhat lost in the problem and have some need to work themselves out of their partially confused state. Since the real payoff comes on the ultimate answer rather than on the initial answer one might find that some persons show no difference in their answers over a long period of time. Either they had unusual insight in the first place or, for some reason or other, they have done no further thinking or work on the problem to which they had already "found an answer earlier." For a given problem maybe one should strive to look for those with the unusual insights in the first place or for those whose answer shows some change with time, especially in the direction of fresh clarification.

The Revision II test findings are relevant on this point. The ratio score of the number of words per idea on this revision task was the best single predictor of the total set of 27 communication criterion scores from 19 live situational tests. A revision type of score on an appropriate type of activity may predict success of performance in science as well as it has done in communication activities. At least it seems that some scientists are continually rethinking and are reworking the area of their interest and revising and improving their statements about their area. Perhaps one needs to identify or develop people who can or will rework -- instead of resist reworking -- the specific field of their interest so that they are continually striving for improved understanding of their own field.

A last comment on the communication research is that a variety of self report techniques proved to be good predictors of actual performance in communication situations. They also added separate valid variance that the paper-and-pencil tests did not measure. At this early stage of work it is certainly recommended that various self report approaches to identifying creativity in scientists and in science students be attempted. For example, it seems that there should be in process at least a few serious attempts to build biographical information blanks designed to separate more creative from other types of scientists. My experience in several areas indicates that a relatively simple self-report approach has proved to be a fruitful predictor and will serve fairly well until one can find more objective measures that will cover the same valid variance.

Creative thinking as inferred from troubleshooting behavior on electronic equipment

The third study is concerned with the troubleshooting of complex electronic equipment which often represents a specialized form of problem solving behavior. Thus, it is reasonable to expect that factors which influence problem solving are similarly effective in troubleshooting.

In some of our recent work with the Maintenance Laboratory of AFPTRC, military electronics technicians were observed and their troubleshooting performance evaluated. The troubleshooting behavior of different electronic mechanics is remarkably varied in spite of their common training. This variability in performance is attributable to a variety of factors, some of which are results of the complexity of the equipment itself. Others are related to variations among the mechanics.

When a mechanic is confronted with an unfamiliar troubleshooting problem, the scene is set for a possible "original" approach. It is at this point that creativity can play its most marked role in troubleshooting behavior. In such situations, less imaginative troubleshooters usually fumble and dawdle until they draw from their training repertoire a complex of behaviors which they fit like keys to an obstinate lock until either the problem yields or the mechanic gives up. The more imaginative person confronted with this situation is apt to come forth with an original approach which may or may not be successful but which often reflects insight, understanding of the equipment, and resistance to tendencies toward stereotypic conceptualization. He is willing, perhaps even eager, to apply "his own" ideas. We are trying to understand these behaviors and develop valid measures in these performance test situations.

Personality and ability characteristics in productive scientific work

The fourth study recently initiated is to be conducted primarily at Wright Air Development Center and Air Force Cambridge Research Center on the personality and ability characteristics necessary for productive scientific work. The first major activity is to identify types of scientific work in these laboratories together with some behaviors thought to be important to each type. Some objective criteria have also been identified which might reflect productivity. Table 2 presents a suggested list of criteria, undifferentiated according to types of scientists. This list was available as a result of preliminary work at the Personnel Laboratory of the Air Force. The task is to improve upon this list and some steps have already been taken in this direction. At least tentatively, we are finding several types of scientists, the roles of each type being somewhat different in the research laboratory. We are also seeking criteria for measuring the success of each different type of scientist, including some common criteria across the types as well as certain criteria specific to each type.

Another activity in process involves a study on the job descriptions of a sample of Air Force research scientists. The work to date indicates that there are several different kinds of research tasks. Some scientists spend more time in supervision and administration, others in equipment design or manipulation of tangible elements, others work with abstract concepts, and others are concerned more with programming or giving direction and relating research to the organizational needs and objectives. However, it is still too early from this approach to try to categorize these activities into final types of scientific jobs.

The work has shown that certain characteristics seem to cut across research tasks and show up in many different kinds of positions. The finding of common characteristics is encouraging but does not necessarily mean we have found elements crucial to creativity. There is, of course, an interest in finding any common characteristics which are related specifically to creativity. Some common elements may not contribute to creativity, whereas others may be necessary to successful research but not sufficient for it. As an example, all the positions studied required advanced education and technical knowledge, but we are all too well aware that having an education and acquiring technical knowledge is certainly not sufficient to insure creative work. Our latest draft on this total study of science jobs is presented in Table 3, at the end of the report.

During the previous conference it was somewhat difficult to talk about creative scientific talent when we often did not have a clear picture about scientific talent as such. This question is arising again in another form, because the initial work at Wright Air Development Center suggests the possibility that originality of some type and degree may be required in each type of scientific work in these research laboratories. Perhaps it may turn out that one task is to identify different types and degrees of creativity in scientific jobs. For instance, creativity may be a minor element in low level jobs in science but the most crucial aspect in certain high level jobs. One wonders whether the current situations in research laboratories might often be organized somewhat on a seniority basis which might stifle the creativity of many of the younger scientists during the period that may otherwise be their most fruitful one.

Later in this project it is hoped that predictors can be identified which will relate validly to these different criteria and that an effective set of predictors will evolve which will differentially classify scientists into various types of scientific work. Table 4, at the end of this report, shows the list from which the work will start in this latter phase of the study. Some thinking about the list in Table 4 has already occurred. For example, one wonders if it might be possible for a person to be so nonconforming that he would never make a satisfactory adjustment and thus never become fruitful in certain laboratory organizations. In terms of the fourth point about excessively ambitious goals, perhaps the effective scientist is the one who sets for himself obtainable short-range goals but is also continually increasing his level of aspiration as he achieves each short-range goal.

I have a few additional speculative comments about creativity. Recently, I listened to the recordings of a research group during a brainstorming session, which in many ways resembles a typical ideational fluency task to which an entire group responds orally. Although I am certainly not persuaded that the persons with the best ideas are always among those who will speak freely in such groups, it is quite evident that the contributions in group meetings of this sort differ widely across the individual members It seems that at least crude quality and quantity measures of each individual's contributions could be readily obtained. It is interesting to follow the group linkage of ideas and note how the associations flow in these sessions. Some persons helped set the stage while others made crucial leaps ahead in the discussion. One thing that seemed to be scorable and related to Guilford's category change is the number of new directions in the discussion started by each individual. Some persons do not slavishly follow the flow of the discussion but are apparently thinking at right angles on an unusual train of thought and then come in later to send the discussion down new and fresh alleys. One person did this several times during the session to which I listened, whereas the contribution of others seemed to be merely minor variations or refinements around already existing themes.

Another relevant area which would be an extension of our communication research is the questioning abilities and questioning and information searching tendencies of a person. Some persons tend to accept existing information and the current outline or scheme for that information whereas others seem to search for every detail of information so that they can then organize the accumulated material into a scheme of their own. In other words, they do not readily accept the existing scheme. It seems that searching or questioning abilities are valuable in finding ambiguity in existing assumptions, structures, and principles in science and in raising questions that point out the ambiguity and therefore the need for further thinking and research on that topic.

Perhaps our search is for the person in science with the "tomorrow mind" instead of the "yesterday mind," as labeled by Kettering. Perhaps we are seeking a person whose primary attention is forward instead of tied to the past, a person who is ready to make progress now -- not "sometime later;" one who some way finds an open channel from the known out into the unknown, and who continually searches and probes for ways to move forward until he eventually finds a succession of open channels leading further and further into the uncharted areas of nature.

C--I was surprised by your correlation of .06 for grades as predictors.

S--I hoped that the report on this finding would "smoke out" other studies or stir up new research on grades as predictors of success in actual scientific work.

Q--Could you say a little bit more about how the criterion ratings were derived?

S--These were typical merit ratings in an organization -- a standard overall kind of rating with five categories. If a man obtained a rating in the bottom category, chances are that he would be singled out as one who might not be a good prospect to retain in the organization.

Q--That would have been the five on your scale rather than the three. Is that right?

S--Yes, the categories presented in Table 1 were the top three categories. None of these people who had been promoted up to the third and fourth levels in the organization obtained ratings lower than that. It appears that these ratings are somewhat related to the status of the workers.

Q--What was your distribution in the five steps on your merit rating scale?

S--In Table 1 you see the distribution of 76 in the top rating category, 121 in the second from the top, 42 in the third from the top, and zero in the two bottom categories. The fourth and fifth categories were on the rating scale, but no raters assigned any of these people to these bottom two categories, so the frequencies found were zero.

C--In the work I reported two years ago, we found that those students who had high grades seemed to do quite well and were highly productive. But there were also a number of people who were getting rather low grades in graduate education who turned out to be much more productive than we had expected. Yet, there was no question about those who had high grades. That was at the graduate rather than the undergraduate level.

S--As I recall, you had somewhat of a triangular shaped distribution, didn't you?

C--Yes.

Q--Did you consider at all the background of the students -- you might say the climate, or any factor that might be influencing their productivity?

S--No study of biographical or situational factors was undertaken. However the sample is large enough and drawn fairly widely nationally in terms of baccalaureate origin, so that many factors would tend to cancel each other out in their undergraduate backgrounds.

Q--You speak of productivity and creativity. Do you think of them as distinct? I more or less thought of them as kind of mixed up together.

S--I made the assumption that among the productive we would find the creative.

Whereabouts among the productive will the creative be found may be one of our most difficult and vital problems. Even though a person may not produce too much, his products may be of real high quality -- that is, we may be searching for high quality producers if you want to think of it that way. A more refined approach may be to narrow down the productive group to the high quality productive subgroup, among whom would be the creative.

Q--I take it you make a distinction, too, between a research man and a creative man?

S--Among research men I think you might find a few highly creative research men. Overall success on the job was being predicted in the first study so this criterion might be more closely related to productivity than to creativity. On this point, however, it would be surprising to find on one hand, an absence of relationship between grades and overall success in a research laboratory and on the other hand, a strong relationship between the same grades and some measure of creativity. My first hunch is that this combination of results would be very surprising.

Q--Were these people in a large number of companies or in one company?

S--They were from one large center with several laboratories. But the study was on the entire research population at that center except for those discarded for lack of transcripts.

Table 2

A Suggested List of Criteria on Scientists

1. Estimated capacity for fulfilling functions as a scientist by:

   a. producing high-level, high-originality ideas.
   b. producing low-level ideas in quantity.
   c. developing techniques for exploring new ideas.
   d. developing and executing research studies.
   e. preparing reports of research studies for a technical audience.
   f. producing technical publications.
   g. producing publications that are influential and important contributions to the literature.
   h. attaining professional recognition in terms of award of prizes, etc.

2. Capacity for fulfilling functions as a member of a profession by:

   a. contributing papers to professional meetings on broad topics or on problems of professional organization.
   b. serving on professional committees or advisory bodies.
   c. being willing to be consulted on problems where professional advice is needed.
   d. participating in seminars and similar activities within the organization.
   e. communicating findings and ideas to the scientific body by written or oral methods.

3. Capacity for exercising leadership in research by:

   a. planning long-term programs of research which show some unity of purpose and of ideas.
   b. supervising others in the scientific aspects of their work.
   c. stimulating others with his own ideas.

4. Capacity for promoting the ideas of others by:

   a. communicating ideas to higher echelons and devising methods of communicating ideas.
   b. seeing the long-term implications of particular researches and discoveries.
   c. making use of personal contacts and other informal channels.

5. Capacity for fulfilling functions as an employee of an organization such as:

   a. recognizing the purposes of the organization.
   b. adjusting his work to the purposes of the organization.
   c. pursuing a consistent program of research which is directed towards a single goal related to the goal of the organization.
   d. cooperating in the reporting system and paper work procedures.
   e. giving technical assistance to others in the development of their research projects.

Table 3

Duties in Scientific Jobs

Planning Activities

- Analyzes needs and requirements of AF and recommends or initiates programs (6)*
- Recommends long range policies and plans (6)
- Plans long range research programs in terms of needs (6)
- Reviews technical findings, recommendations, and reports (11)
- Evaluates bids (3)
- Stimulates interest among outside scientists in AF problems (4)
- Represents branch in conferences (external) (20)

Administrative Activities

- Formulates policy and procedure on technical and administrative operations (10)
- In absence of higher authority executes functions of position (5)
- Administration of program (8)
- Plans procurement, installation, maintenance, and arrangement of physical facilities (11)
- Initiates purchase requests (17)
- Develops budget estimates (16)
- Reviews correspondence (5)

Supervisory Activities

- Supervises personnel (12)
- Interprets policy of higher authority and orients group research in terms of this policy (9)
- Generates organizational action (2)
- Coordinates internal technical activities (4)
- Selects and assigns personnel (8)
- Assigns, gives guidance, and reviews research tasks (6)
- Formal and informal observation of underway research (6)
- Supervises performance of tests and handling of results (6)

Research Activities

- Recommends or suggests new lines of research (6)
- Investigates, analyzes and evaluates research ideas (4)
- Evaluates proposed projects and recommends emphasis (15)
- Formulates, originates, plans, and develops internal research (33)
- Initiates, delegates, directs, guides, supervises, and coordinates internal research (33)
- Formulates, initiates, and directs external research (9)
- Appraises present research (12)
- Monitors research contracts (27)

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*Frequency of appearance of activity in written job descriptions.

    - Reviews progress reports (15)
    - Provides advice and guidance (external) (10)
    - Liaison and inspection of contracts (10)
- Plans and initiates investigations (8)
- Performs research investigations (5)
- Performs research (33)
- Prepares progress reports (3)
- Organizes, tabulates, and analyzes data (4)
- Maintains logs and records (2)
- Performs and evaluates tests (4)
- Designs equipment or apparatus (14)
- Constructs and erects apparatus (7)
- Makes design layouts and sketches (4)

Miscellaneous

- Technical consultant (external) (14)
- Confers with outside experts (5)
- Acts in liaison capacity (external) (2)
- Maintains current knowledge of field:
    - Studies literature (appraises and evaluates for application) (35)
    - Attends conferences and meetings (internal) (4)
    - Participates in conferences (external) (13)
    - Attends formal training course (2)
    - Maintains contacts in field (16)
- Participates and gives recommendations at technical meetings and conferences (internal) (12)
- Technical consultant (internal) (40)
- Acts in liaison capacity (internal) (4)
- Prepares technical reports (36)
- Writes scientific papers (36)
- Works as part of team (3)

Mental Demands of Scientific Jobs

Judgment -- many types (35)
Originality (31)
Resourcefulness (21)
Knowledge (up to date, general, broad) (20)
Creative thought (20)
Initiative (17)
Ingenuity (10)
Tact (7)
Imagination (creative) (7)
Leadership ability (6)
Executive ability (5)
Professional skill (4)
Ability to think in abstract concepts (4)
Ability to think systematically and scientifically (4)
Administrative ability (4)
Foresight (3)
Ability to reduce generalities (3)
Ability to integrate scientific conclusions with practical factors (3)
Ability to integrate field of specialization with other fields (3)
Supervisory ability (2)
Ability to obtain cooperation (2)
Desire to increase knowledge
Organizing ability
Ability to present oral and written reports
Inventiveness
Versatility
Forceful persuasive argumentativeness

Table 4

Some Personality and Ability Characteristics that Might be Related to Productivity in Science

Methods will be explored for identifying important personal characteristics which differentiate between the productive and unproductive scientific workers. The problem will be first that of identifying variables that discriminate between scientists of equal intellectual ability and equal training but who vary in productivity as measured by the dimensions defined in the previous phase. Variables will be identified which it is believed are related to the dimensions of scientific productivity discovered in the previous phases of the research. Such variables might include those listed below:

1. Differences in success orientation or the degree to which the scientist expects to succeed. Differences in failure orientation should also be studied for this may not be simply the opposite end of the scale to success orientation.

2. Compulsiveness insofar as it makes the scientist dissatisfied and unwilling to report results which do not fit a theory to perfection.

3. Fear of criticism.

4. Excessively ambitious goals. It is suspected that some scientists are unproductive because they want to study only the big problems which cannot be handled yet with available techniques.

5. Degree of belief in the worth of own ideas. This is an aspect of the self concept which, with other aspects, may partially determine productivity.

6. Degree of achievement motivation.

7. Inability to stick to one goal for a sufficient length of time -- possibly manic tendencies.

8. Need for approval and status recognition.

9. Previous history and long established habits of productivity.

10. Differences in originality, ideational fluency, and sensitivity to problems (as defined by Guilford).

11. Present age, and age on completion of education.

12. Background differences.

The variables listed above relate mainly to scientific productivity in so far as this involves the production of scientific knowledge. Additional lists of variables will be prepared which are related to other phases of the scientists' contributions to the work of an organization.

VARIABLES RELATED TO CREATIVITY AND PRODUCTIVITY AMONG MEN IN TWO RESEARCH LABORATORIES[1]

Donald W. Taylor
Yale University

S--Over the past seven years, first at Stanford University and more recently at Yale, I have been engaged in research which has involved primarily experimental studies of problem solving -- that is, studies of individuals or groups solving problems which have logically correct solutions. In the course of this research, however, some four or five studies of creative thinking have also been carried out.

I should like to describe here today the two of these studies which appear to be most relevant to the area with which this conference is concerned. Perhaps I should note somewhat parenthetically that this work was actually completed several years ago. However, since reports of these studies have not been previously published, they may be of interest to this group.

The first and more extensive study was made possible through the cooperation of the Navy Electronics Laboratory at San Diego; the second and more limited study, through the cooperation of the Naval Ordnance Test Station at China Lake, California. I should like to acknowledge the assistance of Arnold M. Small, who was at the time Head of the Human Factors Division at NEL, and also that of James A. Nielson, who was then Assistant Head of the Personnel Department at NOTS. Finally, I should particularly like to acknowledge the work of Edward J. Sweeney, who as my research assistant, aided not only in the collection of the data, but also carried out the rather extensive statistical analyses required.

Perhaps I should explain that many analyses of the data, in addition to those that are reported here, were carried out. But since the results of these additional analyses do not alter materially the conclusions reached, and since I do not wish to try your patience unduly, I am omitting them from this report.

Both the NEL and the NOTS studies involved an exploration of the relation of certain test and other variables to the creativity and productivity of men engaged in research or development work. A total of 103 men was included in the group studied at NEL. Over half of these held positions as electronics engineers, and a large part of the remainder were electronics scientists. All were college graduates and about a third had taken graduate work, a small number having completed the doctorate. Most of the men were between 25 and 44 years of age. They held civil service grades ranging from GS-5 to GS-13, and had been employed at NEL for periods ranging from less than one year to as much as ten years.

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[1] The research reported here was carried out under Project NR 150-149 and supported by Contract N6onr 25125 between Stanford University and the Office of Naval Research. Permission is granted for reproduction, translation, publication, use, and disposal of this article in whole or in part by or for the United States Government.

The group studied at NOTS was somewhat more homogeneous, in that it included only men holding positions as physicists, and only those in grades GS-5 to GS-9. Actually, the 66 men included in the study represented nearly all those who met these two criteria who were employed at the station at the time.

Check-List Rating Scales

The research design required first of all that measures be obtained of the creativity and productivity of the men being studied. Consideration was first given to the official merit ratings then available in the laboratories. However, the form then being used both at NEL and at NOTS yielded measures which were quite inappropriate for our purpose. The variables rated were not suitable, too many variables were included on the form, and most important, each variable was rated on only a three-step scale with the majority of the ratings having the same value. Accordingly, new forms were constructed for use.

The Thurstone procedure for constructing attitude scales is undoubtedly familiar to most of you. I believe that Richardson was the first to suggest that this procedure be used for constructing rating scales. Some evidence is available that so-called check-list rating scales constructed by this method yield considerably higher inter-rater reliabilities than do more familiar types of rating scales. For this reason, this procedure was used to construct two equivalent forms of a check-list scale for rating creativity in research or development work, and also two equivalent forms for rating productivity.

Initially, some 206 statements concerning creativity or originality and 273 concerning productivity were collected from a variety of sources. These were edited and typed on 3 x 5 cards, one statement to a card. Working individually, 44 judges sorted the statements about creativity into one of seven piles. Each judge was instructed in part as follows:

> On the table there is a set of cards. On each card is a statement that might be made about a man engaged in research -- for example, "He is very skillful in designing experiments."
>
> On the table there is also a cardboard scale, the steps ranging from "1" to "7." This scale is to be thought of as a scale representing degrees of CREATIVITY or ORIGINALITY in research. Step "1" represents very low, and Step "7" very high, creativity or originality. Steps "2" to "6" are steps equally spaced between the extremes.
>
> Your task is to read the statements on each card and decide in which of the seven steps it belongs ....

In similar fashion, 45 judges (the same 44 plus one more) sorted the statements about productivity into one of seven piles, ranging in equal steps from least to greatest productivity. Those serving as judges were college undergraduates. Although it would have been preferable to have employed physical scientists or engineers as judges, it was not feasible to obtain the cooperation of a sufficient number for the required amount of time.

A frequency distribution was obtained for each statement, representing the piles into which it had been sorted by the 44 (or 45) judges. The median of this distribution was taken as the scale value for the statement. Those statements whose distribution showed the least dispersion were, of course, the least ambiguous in that they were the statements with respect to which the judges agreed best in sorting. From the 206 original statements concerning creativity were chosen the 79 showing the least dispersion and hence the least ambiguity. From the 79, two sets of 24 were chosen in such a way that they covered the scale in as nearly equal steps as possible. These two sets were arranged in semi-random order to provide two equivalent forms, C-1 and C-2, of a check-list scale for rating creativity. (See Figures 1 and 2 presented at end of report with all other figures.) In similar fashion, equivalent forms, P-1 and P-2, were constructed for productivity. (See Figures 3 and 4.)

In parentheses following each statement is given the scale value for that statement. This scale value is simply the median (multiplied by 10 to eliminate decimals) of the distributions obtained in the original sorting. These scale values, of course, did not appear upon the forms actually employed by the raters. In using a check-list rating scale, the rater simply checks each statement which applies to or describes the man being rated, and leaves all others blank. The rating is simply the median of the scale values of the statements checked.

Each of the more than 100 participants in the NEL study was rated on both form C-1 and on P-1 by both his Section Head (or Branch Head) and his Branch Head (or Division Head), working independently. To obtain these ratings, I made appointments with each of the more than 30 supervisors individually to discuss the nature of the forms, to emphasize that the ratings were confidential and would be used for research purposes only, and to leave the necessary forms together with a set of instructions. The degree of cooperation obtained is indicated by the fact that all of the ratings requested were returned by all of the supervisors.

Each man thus was rated both by his immediate supervisor and by his secondary supervisor. The mean rating for all men on creativity by their immediate supervisors was 42.6 and by their secondary supervisors 39.8, with standard deviations of 10.4 and 10.5 respectively. The mean ratings on productivity were 46.4 and 44.2, with standard deviations of 8.4 and 7.7 respectively. The correlation between the rating of each man by his immediate supervisor and by his secondary supervisor was .57 for creativity and .49 for productivity. The Spearman-Brown formula yields an estimated reliability for the mean of the two supervisors' ratings of .73 for creativity and .66 for productivity. It should be stated here that these inter-rater correlations probably underestimate the reliabilities of the ratings of the immediate supervisors. As will be seen later, the ratings of the immediate supervisors were more predictable than were the means of the ratings by immediate and secondary supervisors. This fact suggests strongly that immediate supervisors may have had a more adequate basis for judgment and hence gave more reliable and more valid ratings than the secondary supervisors, possibly even to the degree that in some cases the mean of the ratings by the two supervisors is less rather than more reliable than that of the immediate supervisor alone.

Unfortunately, data were not obtained on Forms C-2 and P-2. Although the method of their construction should make them equivalent to C-1 and P-1 respectively, this remains to be demonstrated. Correlations between ratings by the same raters for the same individuals on two equivalent forms would provide what might be a more adequate estimate of the reliability of the rating procedure.

Ratings of creativity were correlated with ratings of productivity to the extent of .67 for those made by immediate supervisors, .60 for those made by secondary supervisors, and .69 for those obtained by taking the mean of the two ratings by the immediate and secondary supervisors. These intercorrelations, of course, must be kept in mind in interpreting the results described below.

Descriptive Rating Scales

Shortly after the task of obtaining ratings upon the check-list scales for the more than 100 men had been completed, I was asked by an NEL administrative committee to assist in the construction of forms which would be suitable for internal laboratory use in the rating of men engaged in research or development work. I agreed to do so, with the understanding that the forms developed could be used in the collection of additional research data. It should be noted that the chairman of the committee was R. D. Russell, and that E. C. Buffington of NEL worked with me in drafting the several scales.

The first step was the selection of the variables to be rated. In the judgment of the committee, the variables important for those men occupying supervisory positions were different from those important for other electronics engineers or scientists. For this reason, different forms were constructed for supervisors and for non-supervisors. After considerable discussion, six variables were selected for rating with each of the two groups. The variables chosen may be seen by examining the completed forms in Figures 5 and 6. The variables chosen for use with supervisors represent a decision of the committee to emphasize the individual's contribution as a supervisor, and to place less emphasis upon his personal technical or scientific contribution.

For each of the six variables on each of the two forms, a rough draft was prepared of a definition and of a seven-step scale, each step on the scale being defined by a series of descriptive phrases. The intention was to construct steps such that the intervals between them would be subjectively equal, and with a range such that all or nearly all of the steps would actually be used in practice. After extensive criticism by the committee and editing of these rough drafts, the scales shown in Figures 5 and 6 were finally adopted.

Supervisors met in groups of five to ten to discuss the nature of the forms, their purposes, and the plan for their trial use. I personally conducted the group sessions for all those supervisors who had previously rated the men participating in the present study. The same supervisors were now requested to rate on the appropriate one of these new forms the same men whom they had rated on the check-list scales some four months earlier. The new forms supplied for this purpose were all stamped in large block letters "For Research Only." It was again emphasized that no one but my research assistant and I would see these ratings. As before, ratings for each man were obtained from both his immediate and his secondary supervisor.

The original goal in constructing each of the seven-step scales was to produce a scale such that the mean rating would be about 4.00, the mid-point of the scale, and such that most of the ratings would be distributed over steps 2 to 6. The mean ratings for the 59 men rated by their immediate supervisors on the form for non-supervisors actually varied from a low of 4.44 for "Initiative" to a high of 4.88 for "Attitude Toward Work." The mean ratings for the same men by their secondary supervisors varied from a low of 4.26 to a high of 4.88 on the same two variables, respectively. The standard deviations for the ratings of the same men by immediate supervisors varied from .87 to 1.09, and by secondary supervisors from 1.00 to 1.25. The means and distributions of ratings for the several scales thus approximate reasonably well those originally intended.

The form for supervisors was employed in obtaining ratings for some 39 men occupying such positions. The mean ratings of these men by their immediate supervisors varied from 5.00 to 5.11 and by their secondary supervisors from 4.41 to 4.92. The standard deviations varied from .98 to 1.45 and from 1.07 to 1.31.

The intercorrelations between ratings by immediate and by secondary supervisors on the form for non-supervisors for 57 men were as follows for the three variables of most present interest: Originality, .59; Quality of Work, .60; Quantity of Work, .56. The Spearman-Brown formula yields an estimate for the reliability of the mean of the ratings by immediate and secondary supervisors of .74, .75, and .72 for these same three variables, respectively.

The intercorrelations among the ratings of these six variables by immediate supervisors for 59 men ranged from a low of .39 between "Quality of Work" and "Quantity of Work" to a high of .69 between "Quantity of Work" and "Initiative" and also between "Originality" and "Initiative." Again, these intercorrelations must be kept in mind in interpreting the results which follow.

Table 1 presents the correlations between ratings of creativity and productivity made on the check-list scales, and ratings of originality, quality, and quantity of work made on the descriptive scales some four or five months later. Any tendency for memory to seriously inflate these intercorrelations would appear to be eliminated, not only by the elapse of time between the two sets of ratings, but also by the fact that the two kinds of forms are quite different. These intercorrelations therefore may be reasonably interpreted as an estimate of the reliability of the rating procedures involved. The correlations between creativity and originality and those between productivity and quantity of work suggest that the reliability of the ratings being employed here are considerably higher than indicated by the correlations reported above between the ratings between immediate and secondary supervisors for the several variables. For example, the correlation between creativity and originality of .71 for immediate

Table 1

Correlations between Check-List and Descriptive Ratings

	N	Originality	Quality of Work	Quantity of Work
Ratings by Immediate Supervisor				
Creativity	58	.71*	.50	.56
Productivity	59	.61	.52	.75*
Ratings by Secondary Supervisor				
Creativity	58	.78*	.68	.56
Productivity	58	.54	.69	.82*
Mean of Ratings by Two Supervisors				
Creativity	56	.83*	.66	.62
Productivity	57	.64	.64	.87*

*Correlation between check-list rating and descriptive rating with respect to what was intended to be essentially the same variable.

supervisors and of .78 for secondary supervisors contrasts with the previously reported correlation between the ratings of immediate and secondary supervisors of .57 for creativity and of .59 for originality. As suggested above, these inter-rater correlations probably underestimate the true reliability of the ratings by the immediate supervisor.

Tests Employed

Five different tests were administered to each of the 103 men included in the group being studied at NEL. These tests are listed in Table 2. The first was Form M of the well-known Vocational Interest Blank for Men constructed by E. K. Strong. As you know, this blank yields scores on about 40 different scales. For the present group, however, the blank was scored only on the Engineering Scale, the one which seemed in advance to be most appropriate for this group. In retrospect, it appears that it would have been desirable to score this set on other scales, but this has not been done.

Table 2

Intercorrelations among Tests*

	Test Number						
	1	2	3	4	5a	5b	5c
Undergraduate Grades for Last 2 Years	.10	.11	.18	.02	.06	.22	.33
1. Strong *Vocational Interest Blank for Men*, Form M: Engineering		.19	.37	.06	.26	.19	.33
2. Terman *Concept Mastery*, Form B			.45	.38	.66	.60	.53
3. Owens-Bennett *Mechanical Comprehension Test*, Form CC				.25	.63	.52	.53
4. *Test for Productive Thinking* (Psychological Corporation)					.45	.40	.26
5. *Test for Selecting Research Personnel* (Amer. Inst. for Res.)							
a. Subtest I					(.83)**	.76	.71
b. Subtest II						(.84)	.73
c. Subtest III							(.67)

*For intercorrelations among tests, N = 103. For correlations between undergraduate grades and the several tests, N varies from 46 to 50.

**Reliability coefficient obtained by computing the odd-even correlation and correcting for double length.

The second test employed was Form B of the *Concept Mastery Test* developed by L. M. Terman for use in his studies of gifted individuals. This test is in two parts, "Synonyms-Antonyms" and "Analogies," and is essentially a high-level verbal intelligence test. This test was selected as one that would be sure to have a sufficiently high ceiling for the group being tested.

Form CC of the Mechanical Comprehension Test was developed by W. A. Owens and G. K. Bennett. It was selected for use because in so far as we knew at the time it was the most difficult test of its kind available and it seemed likely to discriminate even among subjects of the ability being tested here.

The Test of Productive Thinking was copyrighted in 1944 by the Psychological Corporation, but thus far has been available only for use in research. The test includes six problems, each of which involves a description of an imaginary happening. The task of the subject is to see how many different consequences or results of the imaginary happening he can think of in the ten minutes allowed for each situation. All completed copies of this test were returned to the Psychological Corporation for scoring by a procedure previously shown to be highly reliable.

The Test for Selecting Research Personnel was developed by the American Institute for Research under a contract with the Office of Naval Research. This test consists of 150 items, each presented in multiple-choice form with five alternatives. Each item presents the subject with the problem and his task is to select the alternative which best solves the problem. A minimum background of one year's college training in physics, chemistry, and mathematics is assumed, and any necessary technical information beyond this level is supplied in the statement of the problem. The test is divided into three parts. Sub-test I is intended to predict chiefly job performances related to formulating problems and hypotheses and planning and designing investigations; Sub-test II is intended to predict behavior related to conducting the investigation and interpreting research results; and Sub-test III to predict behaviors related to preparing reports, administering research projects, and accepting organizational and personal responsibility. The three sub-tests require 65, 95, and 50 minutes. Because they are intended to measure rather different things, the three sub-tests were scored separately.

Intercorrelations among the five tests are presented in Table 2. These intercorrelations are all positive, as might be expected, with those between the Strong and the other four tests being the lowest, which was also expected.

Transcripts of undergraduate grades were available for only about half of the men to whom the tests were administered. Table 2 presents for this smaller group the correlations between undergraduate grade averages for the last two years of college and each of the several tests. These correlations are perhaps lower than might have been anticipated.

Correlation between Tests and Criterion Ratings

Table 3 presents the correlation between each of the several tests and the check-list ratings of creativity and productivity. Perhaps the most surprising finding is the almost complete lack of correlation between the scores on the Engineering Scale of the Strong Vocational Interest Blank and these criterion ratings.

Significant correlations were obtained between each of the last three tests and either the ratings of creativity made by immediate supervisors or the means of the ratings of creativity made by the two supervisors. It is of interest to note that, at

Table 3

Correlations between Tests and Check-List Ratings*

	Ratings by Immediate Supervisors		Mean of Ratings by Two Supervisors	
	Creativity	Productivity	Creativity	Productivity
Undergraduate Grades for All 4 Years	.26	.22	.32**	.16
for Last 2 Years	.29**	.26	.35**	.22
1. Strong Vocational Interest Blank for Men Form M: Engineering	.03	.01	.02	.00
2. Terman Concept Mastery, Form B	.20	.18	.18	.08
3. Owens-Bennett Mechanical Comprehension Test, Form CC	.29**	.20**	.25**	.09
4. Test of Productive Thinking (Psychological Corporation)	.24**	.16	.20**	.15
5. Test for Selecting Research Personnel (Amer. Inst. for Res.)	.36**	.19	.33**	.12
a. Subtest I	.30**	.14	.25**	.04
b. Subtest II	.33**	.17	.32**	.12
c. Subtest III	.31**	.20	.30**	.18

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*For correlations between tests and check-list ratings, N varies from 93 to 103. For correlations between undergraduate grades for all 4 years and check-list ratings, N = 45; for correlations between grades for last 2 years and ratings, N = 51.

**Significant at .05 level.

least with these tests, the ratings of creativity proved to be consistently more predictable than those of productivity. It is also of interest that the correlations between each of the three sub-tests of the Test for Selecting Research Personnel and creativity are almost as high as those between the whole test and this criterion. This fact, taken together with the fact that the whole test requires three and one-half hours to administer, suggests the desirability of exploring further whether one of the three sub-tests may not be an adequate substitute for the full test.

As previously reported, those included among the 103 to whom these tests were administered ranged in civil service grade from GS-5 to GS-13. Question may be raised as to what result would be obtained if the correlations between tests and criterion ratings were computed separately for each grade. This, in fact, was done for grades GS-7, GS-9, and GS-11, which included 19, 24, and 26 men respectively. The results, however, are difficult to interpret because of the relatively small numbers on which these correlations are based. For example, the correlations between the Test of Productive Thinking and the ratings of creativity by the immediate supervisor were .62, .41, and .17 for the three grades separately, as compared to a correlation of .24 for the entire group. The correlations for these same three grades respectively between the same ratings of creativity and the Test for Selecting Research Personnel were .45, .23, and .30 as compared to a correlation of .36 for the entire group. In the latter case, the correlation for the entire group seems to represent reasonably well those for the three separate grades, whereas in the former it does not. Is this discrepancy in the former of importance, or only a function of the relatively small sample involved?

One fact to be kept in mind in assessing the magnitude of the correlations reported in Table 3 is the fact that the criteria being predicted have rather limited reliabilities. Suppose, for example, that one accepts the correlation of .57 reported above between the ratings of creativity by immediate supervisors and those by secondary supervisors as an estimate of the reliability of the former. If one uses this figure to correct for attenuation in the criterion only, the reported correlation of .36 between the Test for Selecting Research Personnel and creativity becomes .48, a figure representing rather sizable practical validity. Reasons, however, have already been given for believing that the correlation of .57 underestimates the reliability of this particular criterion. A better estimate of the validity coefficient which would be obtained with this particular test if perfectly reliable ratings of creativity were available probably is somewhat less, therefore, than .48, but well above .36.

Table 3 also presents correlations between undergraduate grade averages and the ratings of creativity and productivity. These correlations were computed for grades for the last two years only, as well as for all four years, because of the suggestion frequently made that the last two years provide a better basis for prediction, a suggestion which appears to find some support in the coefficients reported in Table 3. Actually, the correlation between the grades for all four years and those for the last two years only was computed and found to be .91. Accordingly, the validity coefficients obtained for the two kinds of grade averages would necessarily be essentially the same, as is the case. The correlations between grades and ratings of creativity, although not very large, were clearly linear. This evidence questions the frequent suggestion that those who make the best grades will be less creative than those whose grades are somewhat lower.

Table 4 presents the correlations between the several tests and the descriptive ratings by the immediate supervisors for those men rated on the form for non-supervisors. The first three columns present the correlations with the ratings of the variables of most interest. None of these correlations is significant. This is true in spite of the high correlations previously reported in Table 1 between the descriptive ratings of these three variables for this same group of men and check-list ratings of creativity and productivity employed as criteria in Table 3. The only suggestion I can make is that restricting to the group those employed in non-supervisory positions materially reduced the range of scores obtained on each of the tests and hence, in turn, the validity coefficients. Essentially the same results as reported in Table 1 occurred when, in a fairly large number of trial computations, the means of ratings by supervisors was used as a criterion in place of the ratings by immediate supervisors only.

The correlations reported between undergraduate grades and these descriptive ratings are of the same order as those reported in Table 3 for the check-list ratings. The size of the group for which transcripts were available in this case, however, was so small that these coefficients are not significantly different from zero.

The Second Study

Each of the 66 physicists in the group studied at NOTS was rated by his immediate supervisor upon the form of the descriptive rating scale appropriate for use with non-supervisors. The Test for Selecting Research Personnel was also administered to each of these same men. Transcripts of undergraduate grades were also obtained for nearly all of this group.

Table 5 presents the correlations of these latter measures with the criterion ratings. The correlation between undergraduate grades for all four years and those for the last two years only was .88, very high, as in the first study. The correlation of these two measures with the criterion ratings was therefore necessarily very similar. The correlation between average grades and the criterion ratings for this group as a whole at NOTS were, if anything, a little higher than those previously recorded in Tables 3 and 4 for NEL.

The number of men at a given civil service grade level for whom transcripts were available at NOTS was large enough to justify computing these correlations between college grade averages and ratings, at least for GS-7 and GS-9. It is of interest to note that in this case the coefficients for these two groups taken separately are consistently higher than those for the total group, which included these two groups plus 10 men at the GS-5 level. Given the limited reliability of these criterion ratings, these particular correlations are rather impressive. Since, however, these correlations are based upon groups including only 25 and 21 men respectively, their sampling error is large.

The correlation for the 66 men at NOTS between the Test for Selecting Research Personnel and the descriptive ratings of originality is appreciably higher than that

Table 4

Correlations between Tests and Descriptive Ratings by Immediate Supervisor for Those Rated on Form for Non-Supervisors*

	Originality	Quality of Work	Quantity of Work	Initiative	Attitude toward Work	Skill with People
Undergraduate Grades for All 4 Years	.36	.35	.17			
for Last 2 Years	.26	.20	.07			
1. Strong *Vocational Interest Blank for Men* Form M: Engineering	.00	.16	-.03	.16	-.08	-.09
2. Terman *Concept Mastery*, Form B	.07	.08	-.15	.04	.03	.22
3. Owens-Bennett *Mechanical Comprehension Test*, Form CC	.15	.20	.07	.21	-.04	.10
4. *Test of Productive Thinking* (Psychological Corporation)	.25	.06	.00	.11	.14	.19
5. *Test for Selecting Research Personnel* (Amer. Inst. for Res.)	.19	.24	-.05	.20	.08	.26

*For correlations between tests and descriptive ratings, N varies from 55 to 59. For correlations between grades for all 4 years and ratings, N = 26; for correlations between grades for last 2 years and ratings, N = 28. The only correlation which is significant at the .05 level is that between Test No. 5 and Skill in Getting Along with People.

previously reported in Table 4 between the same two variables for the group of about 59 men at NEL. It is of the same order as the correlations reported in Table 3 between this test and check-list ratings of creativity for a larger group at NEL. The correlations between this test and quality of work for this group of physicists, however, is somewhat larger than the analogous correlation reported in Table 4, or the correlation of this test with the check-list rating of productivity reported in Table 3 for the NEL group.

Table 5

Correlations between Undergraduate Grades, Test for Selecting Research Personnel,and Descriptive Ratings for a Group of Physicists

	Originality	Quality of Work	Quantity of Work	Initiative	Attitude toward Work	Skill with People
Undergraduate Grades for All 4 Years (56)*	.24	.22	.31**	.31**	.28**	.31**
for Last 2 Years (56)	.21	.26**	.34**	.31**	.24	.28**
GS - 7 Only (25)	.37	.44**	.55**	.44**	.38	.33
GS - 9 Only (21)	.23	.41	.35	.38	.35	.45**
Test for Selecting Research Personnel(66)	.31**	.31**	.14	.13	.13	.21
GS - 7 Only (28)	.35	.23	.17	.00	.12	.13
GS - 9 Only (26)	.34	.50**	.04	.32	.11	.25

*N for each group is given in parentheses

**Significant at .05 level.

The correlations between this test and the two ratings of most interest, originality and quality of work, appear if anything to be somewhat higher when computed separately for those in grades GS-7 and GS-9. Again, because of the small size of these subgroups, the sampling error must be kept in mind. Nevertheless, these data for the NOTS group, taken together with those obtained at NEL, appear to provide encouraging support for the use of the Test for Selecting Research Personnel for predicting creativity and productivity in laboratories of this kind.

Biographical Information

Each of 94 men at NEL filled out a biographical questionnaire. The 50 questions included in this questionnaire are shown in Figure 7. The blank employed included, in addition to these questions, places for recording name, age, and certain other identifying information together with instructions emphasizing that information obtained on the blank would be used for research purposes only, and that none of the information would be given to anyone at NEL.

The purpose of this part of the study was to determine whether any significant relationship could be demonstrated between creativity and productivity on the job and the answers given to questions often asked in selecting people for employment in such laboratories. Many of the 50 questions were selected for inclusion because they were of this type. Some were chosen because evidence from other studies suggested, often indirectly, that the kinds of answers given to them would be related to success on the job. A few of the questions, including, for example, Questions 21 and 34, were included simply on the basis of my own personal hunches.

On the basis of the results already described, the ratings of each man by his immediate supervisor on creativity and productivity, employing the check-list scale, were chosen as the criteria to be used in the present analysis. Three of the questions, Nos. 22, 24, and 25, turned out to yield information which could not be usefully analyzed. The answers to each of the other 47 questions were subjected to appropriate statistical analysis to determine whether the kind of answer given significantly related to the two criteria employed.

Figure 8 summarizes the results obtained. The first column lists questions, answers to which correlated with either or both of the criteria at the .10 level of significance or better. Included are 20 out of the 47 questions analyzed. Of these 20, 13 are significantly related to either or both of the criteria at the .05 level or better.

The fourth and fifth columns of Figure 8 indicate which answers were classified as favorable and which as unfavorable in carrying out the statistical analysis. Thus, for example, the answers to Question 29 were significantly related at the .01 level to both creativity and productivity. Those men who reported that their family's income when they were 10 or 12 years old was about $3,000 a year tended to score significantly higher with respect to both criteria than those who reported either lower or higher incomes. This finding seems consistent with that of other previous studies which report a tendency for research men to come predominantly from middle-income families. (Over two-thirds of these men would have been between 10 and 12 years of age sometime between 1928 and 1942, a period during which $3,000 a year might appropriately be described as middle-income.)

The answers to Question 36 also related significantly to both criteria at the .01 level. Here, those who reported reading one or more books a week when 10 or 12 years of age, excluding those assigned at school, were more likely to be rated high on creativity and productivity than those who reported less frequent reading.

Question 14 perhaps deserves special comment. The answers to this question concerning the subjects liked best in college related significantly at the .01 level to creativity, although no significant relation to productivity was found. What is of interest is that the favorable answers to this question included mathematics, physics, electronics, and other physical sciences -- in other words, those physical science courses with a rather heavy theoretical emphasis. The unfavorable answers included, not courses in the humanities or social sciences, but rather those in radio, electricity laboratory courses in electricity or engineering -- in other words, those courses with strongly empirical or practical emphasis.

Question 39 deserves mention here even though answers to it were related significantly to creativity only at the .10 level and not at all to productivity. The unfavorable answer to this question as to whether the individual was ever a licensed radio amateur was that he had been, and that he had spent more of his time in building and rebuilding the gear than in communicating with other amateurs. The important point here is that this answer is the one that is usually regarded as favorable by many of those who use this question in interviewing men for possible employment in laboratories like NEL.

In closing discussion of these particular results, I cannot resist mentioning Questions 21 and 34 -- questions which, as I mentioned earlier, I included on the basis of personal hunches. Those who reported dating three times a week or more, or being married, during their last two years in college were rated as significantly more creative than those who reported dating less frequently. My hunch had been that creativity would tend to be associated with early maturity, a hunch to which this result gives at least some support. Those who reported that they felt that they had failed to meet the high standard of achievement set by their parents were more likely to be rated as highly productive than those who felt that they had fulfilled, surpassed, or now expected to fulfill the standard set by their parents. This finding is consistent with my expectation based upon the observation that often individuals who are highly regarded by others tend to be more critical of their own performance than do those less well regarded.

The results summarized in Figure 8 must, of course, be cross-validated on another and comparable group of men before any importance can be attached to them. I regret that I must report that the one attempt which we have made thus far at cross-validation yielded generally negative results.

The 66 physicists studied at NOTS also filled out this same questionnaire. The rating of each of these men on originality by his immediate supervisor on the descriptive rating scale was employed as a criterion in an analysis of the predictive value for this group of the questions listed in Figure 8. When the same classification of favorable and unfavorable answers was employed as for NEL, none of these questions was found to be significantly related at the .05 level to the criterion of originality. Several factors may account for this result. First, this particular criterion may be less reliable than that employed at NEL. Secondly, the reduction in the size of the group from nearly 100 to 66 reduces the sensitivity of the significance test employed. Thirdly, it may be that physicists differ in essential ways from electronics engineers and electronics scientists in the kinds of biographical data which may be expected to relate to creativity or productivity. Finally, while several items met the .05 level of significance in the NEL study, five per cent of the total 47 items would be expected to meet this level due to the nature of the significance test used even though, in fact, they have no true relation to the criterion.

I have reported the results of the analysis of biographical information in some detail in the thought that they may furnish leads for further investigation -- certainly not in the thought that the results obtained with the NEL group provide any real basis for use of these questions in selecting men for employment in such laboratories.

Postscript

About 20 minutes was devoted to a description of two recently completed experimental studies concerned with creative thinking. Since the results of both of these studies have since been described in more detail elsewhere, they will not be summarized here. Instead, the reader is referred to the following two technical reports listed in the References at the end of the conference report:

> Taylor, D. W., Berry, P. C., & Block, C. H. Does Group Participation when Using Brainstorming Facilitate or Inhibit Creative Thinking?
>
> Taylor, D. W., & Block, C. H. Should Group or Individual Work Come First on Problems Requiring Creative Thinking when Equal Time Is Devoted to Each?

Figure 1

Check-List Rating Scale for Creativity: Form C-1

Man Rated: ______________________ Rated by: ______________________

Place a check mark in the space to the left of each statement which applies to or describes the man being rated. Statements which do not apply should be left blank.

( ) He often introduces minor innovations in his work but rarely, if ever, makes a markedly original contribution. (33)

( ) He contributes more of his own ideas to the problems he works on than does the ordinary worker. (51)

( ) Given an unfamiliar problem, his first impulse is to consult a book or another person. (17)

( ) By comparison with other people in such a job, he is outstandingly creative. (66)

( ) Like most of us, he has occasionally devised an improved method or piece of equipment. (42)

( ) He never has an idea of his own to suggest. (10)

( ) Some of his ideas, while original enough, are also silly or bizarre. (37)

( ) He shows signs of being one of the most creative men in this work that I have known. (68)

( ) He does not have a great number of new ideas. (25)

( ) He frequently has ideas. (45)

( ) He has suggested many entirely new problems. (61)

( ) He is somewhat hesitant about trying to work through a new problem entirely on his own. (27)

( ) Now and then, he works out a somewhat ingenious hypothesis. (49)

( ) Characteristically, even when faced with new problems of some complexity, he tries to think things through in his own terms. (56)

( ) He seldom contributes new ideas. (20)

( ) Once in a while he has an original idea. (32)

( ) More than once he has shown us new ways of looking at results. (54)

Figure 1 (continued)

( ) Left to himself, he might have difficulty thinking up problems to investigate. (22)

( ) Invariably his approach to anything is original and fresh. (63)

( ) He does an adequate, but not an outstanding, job of outlining new research proposals. (39)

( ) His ideas are more likely to be conservative, rather than revolutionary. (28)

( ) He worked out on his own, applications of his results to other problems or fields. (58)

( ) He requires detailed instructions before he sets about a new job. (14)

( ) He is something of an independent thinker. (47)

Figure 2

Check-List Rating Scale for Creativity: Form C-2

Man Rated: ______________________________ Rated by: ______________________________

Place a check mark in the space to the left of each statement which applies to or describes the man being rated. Statements which do not apply should be left blank.

( ) He has often proposed changes in an experimental procedure. (54)

( ) He is imaginative but the quality of his ideas is poor. (34)

( ) He has little knack for thinking up new things. (17)

( ) His inventiveness is his strongest trait. (66)

( ) He frequently asks the advice of his co-workers. (27)

( ) He pointed out the ways in which a technique could be used beyond its originally intended purpose. (58)

( ) He sometimes proposes new lines of investigation. (46)

( ) He does a competent job because he is skillful and experienced rather than because he is an original thinker of some proportions. (25)

( ) He has proposed on his own a whole avenue of investigation. (63)

( ) He always must be told or shown what to do. (11)

( ) Usually his original ideas are paltry -- in his own thinking, he never achieves a large synthesis of many things. (32)

( ) He is inclined toward theoretical, speculative aspects of the work. (50)

( ) He has about average ability to conduct an investigation on his own. (38)

( ) He follows established procedures consistently. (14)

( ) He can come out with some pretty strange ideas. (42)

( ) Any proposal he draws up or submits is bound to be full of fresh ideas. (61)

( ) Most of his ideas are modified versions of what someone else has said or thought. (22)

( ) His suggestions usually turn out to be good ideas. (52)

Figure 2 (continued)

( ) He would do better in testing and development work than in pure research. (28)

( ) He is an excellent creative thinker. (69)

( ) He is a good worker but he doesn't have much imagination. (20)

( ) Occasionally, he has come forth with some very original interpretations of results. (48)

( ) He is moderately successful at solving problems and eliminating difficulties that arise in an investigation. (40)

( ) He originated several methods for dealing more effectively with our research problems. (56)

Figure 3

Check-List Rating Scale for Productivity: Form P-1

Man Rated ______________________________ Rated by: ______________________________

Place a check mark in the space to the left of each statement which applies to or describes the man being rated. Statements which do not apply should be left blank.

( ) His output is somewhat below what one expects from the average worker. (28)

( ) He does satisfactory work on assigned problems. (41)

( ) He is one of our best men. (63)

( ) He never seems to accomplish anything. (12)

( ) He is on the borderline; capable of fairly good or average work but inclined to fall below that level. (30)

( ) He often does an outstanding job, even under adverse conditions. (60)

( ) The work he hands in is careless and superficial. (17)

( ) His work is always done on time. (52)

( ) He gets right down to work and doesn't waste time. (54)

( ) In terms of quality, his work is about average. (39)

( ) He has to be prodded continuously to keep him going. (19)

( ) Both in terms of quantity and quality, his work leaves nothing to be desired. (69)

( ) His work has to be checked for errors. (23)

( ) He works steadily and tries to be thorough. (44)

( ) He has an exceedingly large output. (67)

( ) He tends to get off on to side issues and to wander from the point of a project. (25)

( ) He struggles along, is fairly productive, and, under the best conditions, does a tolerable job. (33)

( ) He never gives up on a problem until reasonable success has been attained. (49)

( ) He seldom gets his projects done on time. (21)

Figure 3 (continued)

( ) He turns out a great quantity of work. (65)

( ) Like most of us, he is inclined to make a few mistakes in his work. (36)

( ) He can solve satisfactorily most of the problems that arise in connection with his work. (47)

( ) His hard work has earned him the respect of his associates. (57)

( ) He takes so long to do his work that sometimes the need for an answer to a problem passes before he is finished working on it. (14)

Figure 4

Check-List Rating Scale for Productivity: Form P-2

Man Rated: ______________________ Rated by: ______________________

Place a check mark in the space to the left of each statement which applies to or describes the man being rated. Statements which do not apply should be left blank.

( ) He does only a fair job. (34)

( ) His work is usually accurate and sometimes achieves an unusual degree of penetration. (51)

( ) He often returns assigned work in better shape than one had believed was possible. (61)

( ) It takes him too long to do a job. (19)

( ) He is fairly competent in the use of techniques and equipment. (45)

( ) He takes forever to do a job. (13)

( ) He produces as much work as the average person in his job would. (40)

( ) He often shows his ability to solve technical problems of considerable complexity. (56)

( ) He is inclined to go to sleep on the job. (16)

( ) He is exceptionally prompt in completing his assignments. (59)

( ) Now and then he falls behind in a work assignment. (31)

( ) He makes a real effort to do a good job. (49)

( ) He is inclined to wander away from the main problem. (25)

( ) He contributes his full share to any project he participates in. (53)

( ) His work is thorough but so slowly done it is usually handed in late. (27)

( ) He has an exceptional work output. (69)

( ) He does a superb job of meeting specifications of an assigned problem. (63)

( ) We would be better off without him. (11)

Figure 4 (continued)

( ) Sometimes the way he handles assigned problems is a little disappointing. (29)

( ) He usually makes allowance for practical considerations. (47)

( ) His work is satisfactory, but could be improved. (37)

( ) He is usually late with his work. (22)

( ) He does the job he is supposed to do. (43)

( ) He is definitely a very superior producer, fairly close to the top. (66)

Figure 5a. Descriptive Rating Scales for Non-Supervisors

evaluation summary

name of employee .... *code* ....

position title and grade .... *date* ....

Instructions: For each item below, carefully consider each descriptive statement and check the box opposite the one that best describes the person being evaluated. You may rightly think that no one of the statements is an exact description of the person, but make the best choice you can. In choosing the best statement, consider the person's entire work performance on that item; don't base your judgment on one or two isolated incidents.

Evaluate *all* employees under consideration on one item before proceeding to the next one; evaluate *all* on the next item before proceeding to the third, etc.

Complete in duplicate; retain original and submit duplicate to your immediate supervisor.

---

quality of work

Quality of work submitted compared to standard of quality expected. Disregard quantity of work and consider the accuracy, thoroughness, neatness, and general degree of technical excellence of his work.

☐ His work is often inaccurate, superficial, or trivial. The quality is below the minimum which should be expected for continued employment in his position.

☐ The quality of his work is just acceptable. Errors are frequent and occasionally serious. The work is seldom thorough, but with careful review is ordinarily usable.

☐ As a rule his work is fairly good, although he makes more mistakes than the average worker. The quality is satisfactory.

☐ His work is of average quality. There are occasional errors, but these usually are not serious; technically his work is good.

☐ His work is definitely above average in quality. He usually can be counted on to do both an accurate and a thorough job.

☐ His work is very good; its accuracy and thoroughness is such that critical review is seldom needed.

☐ His work is outstanding in accuracy, thoroughness, and technical excellence.

quantity of work

Total quantity of work produced compared to the amount expected in the type of position and at the level of the person considered. Speed of work; success in meeting schedules and deadlines.

☐ His output of work is well below the amount expected of a person in his position. A very slow worker; seldom gets a job done on time.

☐ He produces just enough work to get by. He is about as likely to get a job in late as on time.

☐ The amount of work he produces is somewhat below average for a person in his position. Frequently gets his work done on time but is occasionally late.

☐ He produces an average amount of of work; usually gets his work done on time.

☐ He produces somewhat more than the average; can be depended upon to meet work schedules and occasionally beats them.

☐ Regularly turns out considerably more work than the average. He is a fast worker who frequently beats work schedules.

☐ He produces an outstanding amount of work; is an exceptionally fast and efficient worker.

initiative; capacity for independent action

Degree to which he assumes responsibility when specific orders are lacking; how well he follows through on a job despite obstacles; relative amount of supervision required.

☐ He always must be told or shown just what to do. Even when given detailed instructions, he sometimes fails to carry them out.

☐ When given explicit instructions he usually carries them out, but unanticipated difficulties make additional instructions necessary. Needs daily supervision and frequent prodding.

☐ Can work fairly independently on a day to day basis, but his supervisor must check successive stages in the program to insure that the work keeps moving. Not a self-starter.

☐ Once given general instruction and started on a problem, he proceeds with only moderate supervision. Usually takes action to overcome minor difficulties and requests assistance when appropriate.

☐ Usually sees what needs to be done and goes ahead with little help. He is resourceful in overcoming most difficulties encountered.

☐ With occasional assistance and very little supervision, he can initiate, plan, and carry out a program. Sees what needs to be done and does it.

☐ He is fully capable of seeing the need for, initiating, planning, and carrying out a program entirely on his own.

Figure 5b. Descriptive Rating Scales for Non-Supervisors

originality

Creative ability, including imagination and inventiveness; number of worthwhile new ideas developed; resourcefulness in developing new or modifying present methods and/or techniques.

☐ He never has an idea of his own and never thinks of modifying an accepted method even if it doesn't fit the situation.

☐ He usually thinks only of standardized or routine approaches, doesn't have much imagination, and seldom contributes new ideas.

☐ Is hesitant about working through a new problem entirely on his own and frequently needs advice of co-workers. Occasionally has an original idea, but usually it is of minor significance.

☐ His ideas often contain some germ of novelty, but are mostly familiar or conventional. Has occasionally devised an improved method or piece of equipment; conducts an investigation on his own with about average ability.

☐ Contributes more ideas to the work than does the average worker, is inclined to raise questions, and enjoys speculating about alternative courses of action. His suggestions usually are good ones.

☐ He has lots of new ideas. Left alone, he would keep continuously busy trying them out. Often points out applications of his own results to other problems or fields; calls attention to uses of a technique beyond its original purpose.

☐ He has exceptional capacity for devising ingenious approaches to problems. He is one of the most creative men in this Laboratory.

attitude toward work

Degree of interest in and enthusiasm for his work; adaptability to demands of the job and to changing work situations. How well does he like his job?

☐ His only interest in his work is the money he receives; often appears to just "go through the motions" while waiting for the end of the day.

☐ His interest in his work is only slight. Is usually distracted by minor interruptions. Daily check-ups are necessary to keep him working.

☐ He is mildly interested in his work, rarely enthusiastic, and occasionally bored. Tends to loaf, avoid assignments or responsibilities, and requires considerable time or effort to adjust to a change in work situation.

☐ Is moderately interested in his work. Puts in a day's work for a day's pay, but does extra work only when requested and not because of personal interest. Willingly accepts assignments and responsibilities, but does not seek them.

☐ He likes his job. Occasionally becomes very interested in a problem and puts in extra time. Adapts reasonably well to the demands of the job or to a change in work situation.

☐ His work is important to him and he gets definite satisfaction out of doing it well. He adapts quickly and easily to changes in the work situation. Undertakes extra work as a matter of course.

☐ He is so deeply interested in his work that Laboratory problems frequently claim his attention outside of working hours. He works effectively in almost any situation.

skill in getting along with people

Cooperativeness, tact, courtesy, friendliness, patience, and tolerance. Success as a team worker. Effectiveness in presenting ideas orally to others.

☐ His lack of skill in getting along with people is such that he must be assigned individual work.

☐ Although few of his colleagues really dislike him, few like him well. He works better alone and is ineffective in presenting his ideas to others.

☐ He is liked by many of his group and can work effectively as a member of a team with the right people. Ordinarily he would not be chosen to represent his group in contacts with others.

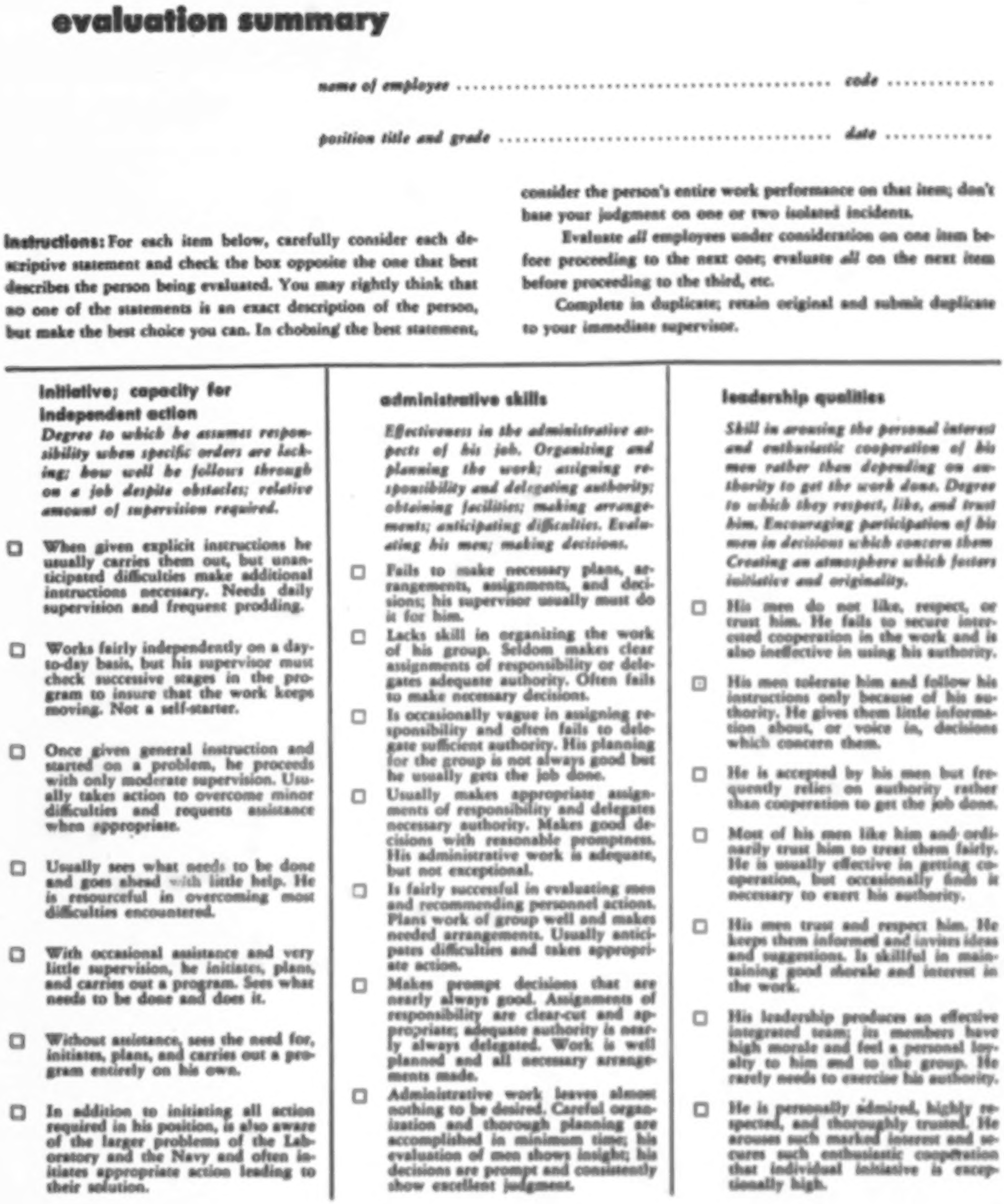
☐ He is liked by most of those in close contact with him and disliked by almost no one. He is reasonably effective in dealing with other groups or with individuals from outside the Laboratory. Works satisfactorily as a team member.

☐ A good team member. He is often successful in getting others to work well together. Makes a good impression, expresses himself well, and is occasionally chosen to represent the group in outside contacts.

☐ Makes friends easily and has considerable skill in handling people. Is nearly always successful in getting effective cooperation among members of a group. Is particularly effective in presenting his ideas.

☐ He is well liked by nearly everyone. His skill in getting others to work together effectively, in handling difficult interpersonal situations, and in representing his group is exceptional.

Figure 6a. Descriptive Rating Scales for Supervisors



evaluation summary

name of employee .... *code* ....

position title and grade .... *date* ....

Instructions: For each item below, carefully consider each descriptive statement and check the box opposite the one that best describes the person being evaluated. You may rightly think that no one of the statements is an exact description of the person, but make the best choice you can. In choosing the best statement, consider the person's entire work performance on that item; don't base your judgment on one or two isolated incidents.

Evaluate *all* employees under consideration on one item before proceeding to the next one; evaluate *all* on the next item before proceeding to the third, etc.

Complete in duplicate; retain original and submit duplicate to your immediate supervisor.

initiative; capacity for independent action

Degree to which he assumes responsibility when specific orders are lacking; how well he follows through on a job despite obstacles; relative amount of supervision required.

☐ When given explicit instructions he usually carries them out, but unanticipated difficulties make additional instructions necessary. Needs daily supervision and frequent prodding.

☐ Works fairly independently on a day-to-day basis, but his supervisor must check successive stages in the program to insure that the work keeps moving. Not a self-starter.

☐ Once given general instruction and started on a problem, he proceeds with only moderate supervision. Usually takes action to overcome minor difficulties and requests assistance when appropriate.

☐ Usually sees what needs to be done and goes ahead with little help. He is resourceful in overcoming most difficulties encountered.

☐ With occasional assistance and very little supervision, he initiates, plans, and carries out a program. Sees what needs to be done and does it.

☐ Without assistance, sees the need for, initiates, plans, and carries out a program entirely on his own.

☐ In addition to initiating all action required in his position, is also aware of the larger problems of the Laboratory and the Navy and often initiates appropriate action leading to their solution.

administrative skills

Effectiveness in the administrative aspects of his job. Organizing and planning the work; assigning responsibility and delegating authority; obtaining facilities; making arrangements; anticipating difficulties. Evaluating his men; making decisions.

☐ Fails to make necessary plans, arrangements, assignments, and decisions; his supervisor usually must do it for him.

☐ Lacks skill in organizing the work of his group. Seldom makes clear assignments of responsibility or delegates adequate authority. Often fails to make necessary decisions.

☐ Is occasionally vague in assigning responsibility and often fails to delegate sufficient authority. His planning for the group is not always good but he usually gets the job done.

☐ Usually makes appropriate assignments of responsibility and delegates necessary authority. Makes good decisions with reasonable promptness. His administrative work is adequate, but not exceptional.

☐ Is fairly successful in evaluating men and recommending personnel actions. Plans work of group well and makes needed arrangements. Usually anticipates difficulties and takes appropriate action.

☐ Makes prompt decisions that are nearly always good. Assignments of responsibility are clear-cut and appropriate; adequate authority is nearly always delegated. Work is well planned and all necessary arrangements made.

☐ Administrative work leaves almost nothing to be desired. Careful organization and thorough planning are accomplished in minimum time; his evaluation of men shows insight; his decisions are prompt and consistently show excellent judgment.

leadership qualities

Skill in arousing the personal interest and enthusiastic cooperation of his men rather than depending on authority to get the work done. Degree to which they respect, like, and trust him. Encouraging participation of his men in decisions which concern them. Creating an atmosphere which fosters initiative and originality.

☐ His men do not like, respect, or trust him. He fails to secure interested cooperation in the work and is also ineffective in using his authority.

☐ His men tolerate him and follow his instructions only because of his authority. He gives them little information about, or voice in, decisions which concern them.

☐ He is accepted by his men but frequently relies on authority rather than cooperation to get the job done.

☐ Most of his men like him and ordinarily trust him to treat them fairly. He is usually effective in getting cooperation, but occasionally finds it necessary to exert his authority.

☐ His men trust and respect him. He keeps them informed and invites ideas and suggestions. Is skillful in maintaining good morale and interest in the work.

☐ His leadership produces an effective integrated team; its members have high morale and feel a personal loyalty to him and to the group. He rarely needs to exercise his authority.

☐ He is personally admired, highly respected, and thoroughly trusted. He arouses such marked interest and secures such enthusiastic cooperation that individual initiative is exceptionally high.

Figure 6b. Descriptive Rating Scales for Supervisors

development of personnel

Effectiveness in developing men under his direction; in identifying and correcting weaknesses in their work; in helping them to acquire knowledge and skills; in preparing them for more responsible jobs in the future.

☐ He has no interest in and gives no attention to the development of men under his supervision.

☐ Lacks awareness of the importance of personnel development, has little understanding of strengths and weaknesses of his men, and shows little skill in helping them improve, though makes attempt when urged by others.

☐ Thinks of personnel development as a minor responsibility and in terms of benefit to his group, rather than to the individual or the Laboratory. Not very effective in developing his men.

☐ Recognizes the need for and is interested in the development of his men, but regards it as a secondary responsibility. Calls attention to needed improvements and occasionally suggests means to achieve them.

☐ Has a genuine interest in developing his men. Is moderately skillful in helping them to recognize needed improvements and in encouraging appropriate action. Is sympathetic to efforts of individuals to acquire skills beyond those needed for present work.

☐ Good understanding of the strengths and weaknesses of his men makes him effective in assisting in their development, including acquiring skills beyond those needed for current work. Encourages them to seek advancement, even though it may take them out of his group.

☐ Sees clearly the importance of personnel development to the individual, to the group, and to the Laboratory. Is particularly effective in using informal interviews and other methods to help his men identify weaknesses and to accomplish needed improvements.

communication and liaison skills

Skill in expressing himself orally and in writing. Effectiveness in representing his group, and in providing information to his men and his superiors.

☐ Often fails to provide important information to his men and his supervisor. Expresses himself very poorly in writing and orally. Is quite ineffective in representing his group.

☐ Expresses himself acceptably in conversation but cannot make a satisfactory formal presentation. Even ordinary letters and reports must be checked. Usually his supervisor must speak for him even inside the Laboratory.

☐ Expresses himself with moderate skill in conversation but with some difficulty in formal presentations. Tends to ignore his responsibility for keeping his men and supervisor informed. Represents group outside the Laboratory only if no one else is available.

☐ Routinely transmits information received, but makes no special effort to secure additional information of value to his men or his supervisor. Expresses himself fairly well orally. Written material of major importance must be checked by his supervisor.

☐ Is conscious of responsibility for keeping men and supervisor informed. Is a good group representative outside the Laboratory. Usually makes a good formal talk. His writing is effective but not polished.

☐ Keeps his men and his supervisor well informed; often digs up information of special interest. Speaks and writes well. Usually chosen as group representative outside the Laboratory.

☐ Is very skillful in expressing his ideas orally and in writing. Is particularly effective in providing appropriate information for his men and in securing from them information and ideas for his superiors. Is an excellent representative for the Laboratory.

originality

Creative ability, including imagination and inventiveness; number of worthwhile new ideas developed; resourcefulness in developing new or modifying present methods and/or techniques.

☐ He rarely has an idea of his own and rarely thinks of modifying an accepted method even if it doesn't fit the situation.

☐ He usually thinks only of standardized or routine approaches, doesn't have much imagination, and seldom contributes new ideas.

☐ Is hesitant about working through a new problem entirely on his own and frequently needs advice. Occasionally has an original idea, but usually it is of minor significance.

☐ His ideas often contain some germ of novelty, but are mostly familiar or conventional. Has occasionally devised an improved method or piece of equipment; directs an investigation on his own with about average ability.

☐ Contributes more ideas to the work than does the average person at his level, is inclined to raise questions, and enjoys speculating about alternative courses of action. His suggestions usually are good ones.

☐ He has lots of new ideas. Left alone, he would keep continuously busy trying them out. Often points out applications of results to other problems or fields; calls attention to uses of a technique beyond its original purpose.

☐ He has exceptional capacity for devising ingenious approaches to problems. He is one of the most creative men in this Laboratory.

Figure 7

Questions Included on Biographical Information Questionnaire

HIGH SCHOOL

1. What subject did you like best when you were in high school? ____________

2. What subject did you like least when you were in high school? ____________

3. During your four years in high school, how many times were you elected to some office (such as class treasurer, secretary of a club, captain of basketball team)?
   ( ) none ( ) two ( ) four or more
   ( ) one ( ) three

How well did you do during high school in each of the following?

4. Football ( ) did not participate ( ) poorly ( ) fairly well ( ) well

5. Basketball ( ) did not participate ( ) poorly ( ) fairly well ( ) well

6. Baseball or softball ( ) did not participate ( ) poorly ( ) fairly well ( ) well

7. Dramatics ( ) did not participate ( ) poorly ( ) fairly well ( ) well

8. Glee club, band orchestra ( ) did not participate ( ) poorly ( ) fairly well ( ) well

9. When you were in high school, which of these did you do most often after school hours?
   ( ) loaf around the house ( ) talk with friends
   ( ) work at part-time job ( ) build things
   ( ) participate in team sports ( ) read

10. During high school, did you get along best with
   ( ) people older than yourself ( ) people younger than yourself
   ( ) people of your own age ( ) people of all ages equally well

11. How old were you when you graduated from high school?
   ( ) 15 or younger ( ) 17 ( ) 19 or older
   ( ) 16 ( ) 18

12. At what age did you first have a date with a girl?
   ( ) 14 or younger ( ) 15 to 17 ( ) 18 or older

COLLEGE (If you did not attend college, check here ( ) and go on to question 26.)

13. In what field did you major in college ? ______________________________

14. What subject did you like best in college? ______________________________

15. What subject did you like least in college? ______________________________

16. How did your parents feel about your going to college?

( ) unfavorable ( ) mildly favorable ( ) it was taken as a
( ) indifferent ( ) strongly favorable matter of course

17. In terms of the amount of time required for outside study and the grades which you received, were your college mathematics courses generally

( ) very easy for you ( ) moderately difficult
( ) usually fairly easy ( ) usually quite difficult

18. During your four years in college, how many times were you elected to some office (such as engineering club secretary, cheerleader, house president, etc.)

( ) none ( ) two ( ) four or more
( ) one ( ) three

19. Did you have a scholarship while in college?

( ) no ( ) yes, one or two years ( ) yes, three or four years

20. What other scholastic, social, or athletic honors did you receive while in college (for example, Phi Beta Kappa, graduation with honors, letter in varsity athletics, editor of school paper, etc.)

____

____

21. About how often did you have dates during your last two years in college?

( ) once or twice a year, or less ( ) once or twice a week
( ) once or twice a month ( ) three times a week or more

22. From what college did you graduate? ____________________ When __________

23. About what fraction of your college expenses did you earn by working either while in college or during vacations?

( ) none, or almost none ( ) about one-fourth ( ) about three-fourths
( ) only a small part ( ) about one-half ( ) all or almost all

GRADUATE WORK (If you have not taken graduate work, check here ( ) and go on to question 26.)

C

24. List below the fields in which you have taken graduate work, approximate number of semester hours in each, universities attended, degrees obtained, and the years in which such degrees were received.

Field	Hours	University	Degree	Year

25. While in graduate school, did you have a scholarship, fellowship, or assistantship?
( ) no ( ) yes

CHILDHOOD

26. In what size town did you live for the longest time during your childhood?
( ) on a farm ( ) a large town (10,000-50,000)
( ) a small town (under 10,000) ( ) a city (over 50,000)

27. Did the home in which you grew up contain
( ) a well-equipped shop, with power tools ( ) a few hand tools
( ) a work bench and many hand tools ( ) no tools
( ) many hand tools

28. During your childhood, what did your father do for a living (that is, was he owner of a small store, manager of a large department store, a bank clerk, a high school teacher, a lawyer, an office supervisor, or just what did he do)?

____

29. About what was your family's yearly income when you were 10 or 12 years old? (Make a guess if you don't know.)
( ) $1,000 ( ) $3,000 ( ) $5,000 ( ) $8,000-10,000
( ) $2,000 ( ) $4,000 ( ) $6,000-7,000 ( ) above $10,000

30. What was the highest level of education which your father completed?
( ) grade school or less ( ) some college or technical school work
( ) some high school work ( ) graduated from college or technical school
( ) graduated from high school ( ) some graduate or professional school work

31. What was the highest level of education which your mother completed?
( ) grade school or less ( ) some college or technical school work
( ) some high school work ( ) graduaged from college or technical school
( ) graduated from high school ( ) some graduate or professional school work

32. Did you lose either of your parents through death, divorce, or separation before you reached high school?
( ) no ( ) yes, through death ( ) yes, through divorce or separation

33. Would you like to be able to do more for your children than your father was able to do for you?

( ) yes ( ) no

34. Do you feel that you

( ) have failed to meet the high standard of achievement set by your parents
( ) have fulfilled the expectations of your parents
( ) have surpassed the standards set by your parents
( ) are now working to, and expect to, fulfill the standards set by your parents

35. Which one of the following kinds of sports or games did you like best as a child?

( ) organized sports (like baseball or basketball)
( ) informal games (like cowboys and indians)
( ) solitary sports (like hiking, playing with toys, or collecting things)

36. When you were 10 or 12 years old, about how many books did you read (not including those assigned in school)?

( ) one or two a year, or less ( ) one a week
( ) one or two a month ( ) two or more a week

37. At what age did you first build some simple piece of electrical apparatus (such as constructing an electromagnet, or wiring a doorbell circuit)?

( ) 9 or less ( ) 13 to 15
( ) 10 to 12 ( ) 16 or older

38. Which of the following would best describe your father's attitude toward research work, science, and scientists?

( ) strongly critical
( ) mildly critical
( ) indifferent
( ) mildly favorable
( ) strongly favorable

GENERAL

39. Were you ever a licensed radio amateur?

( ) no ( ) yes

If so, did you spend more of your time
( ) communicating with other amateurs, or
( ) building and rebuilding the gear

40. Excluding the one in which you are now engaged, what other occupations have you at any time seriously considered choosing as a life career?

____

____

41. At what age did you choose your present occupation? ________

42. Do you expect to spend the rest of your life in your present occupation?
( ) yes ( ) probably not
( ) probably ( ) no

43. Which one of these men do you admire most?
( ) Henry Ford ( ) Winston Churchill
( ) Thomas Edison ( ) Albert Einstein

44. Which of these describes you best?
( ) self-confidence is one of my strongest traits
( ) I am usually self-confident
( ) I often lack self-confidence
( ) lack of self-confidence is a major handicap for me

Which of each of the following pairs is more important to you in your work? Check the first space if the item to the left is more important, the second space if they are equally important, and the third space if the item to the right is more important.

45.	Steady work	( )	( )	( )	Opportunity for promotion
46.	Recognition for work well done	( )	( )	( )	Good salary
47.	Knowledge of what is expected	( )	( )	( )	Opportunity to work out own ideas
48.	Opportunity to learn new things	( )	( )	( )	Pleasant working conditions
49.	Good supervisor and congenial fellow-workers	( )	( )	( )	Sense of intellectual achievement

50. Rank the following items in the order of their interest to you. Place a "1" in front of the most interesting, a "2" in front of the next most interesting, a "3" in front of the next, and a "4" in front of the least interesting.

_____People _____Money _____Things _____Ideas

Figure 8

Questions Whose Answers Related to Ratings of Creativity and of Productivity at the .10 Level of Significance or Better

Question Number	Level of Significance at Which Related to Creativity	 Productivity	Favorable Answer	Unfavorable Answer
3	-	.10	none, one, three, four, or more	two
4	-	.10	did not participate, well	poorly, fairly well
5	-	.05	fairly well	did not participate, poorly, well
6	-	.05	did not participate, poorly, well	fairly well
11	.10	.10	18 or younger	19 or over
14	.01	-	mathematics, physics, electronics, communications, other physical sciences, other	radio, electricity, electrical laboratory, engineering laboratory, engineering
15	-	.10	mathematics, mechanical drawing, economics, business, ROTC, physical education, none	history, political science, psychology, sociology, chemistry, language, composition, speech, education
21	.05	-	3 times a week or more, married	once or twice a week or less
23	.10	-	about one-fourth, about one-half	only a small part or less, about three-fourths or more
27	.05	.05	well-equipped shop..., work bench..., many hand tools, few hand tools	no tools
28	-	.05	all except those listed under Unfavorable in the next column	semi-skilled, clerical, unskilled, father died, parents separated, unemployed, unknown

Question Number	Creativity	Productivity	Favorable Answer	Unfavorable Answer
29	.01	.01	$3,000	$2,000 or less $4,000 or more
31	-	.01	completed whatever educational unit attempted	failed to complete highest educational unit attempted
34	-	.05	failed	all other alternatives
36	.01	.01	1 a week or more	1 or 2 a month or less
39	.10	-	no, yes: communicating with other amateurs	yes: building and re-building the gear
43	.10	-	Henry Ford, Winston Churchill	Thomas Edison, Albert Einstein
45	.05	-	equally important, opportunity for promotion	steady work
49	-	.05	equally important, good supervisor...	sense of intellectual achievement
50	.10	-	"ideas" ranked first	other rankings of "ideas"
	.05	.05	"things" ranked second or third	"things" ranked first or fourth

SOME EFFECTS OF CULTURAL, SOCIAL, AND EDUCATIONAL CONDITIONS ON CREATIVITY

B. S. Bloom
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S--The very title of this conference, "The Identification of Creative Scientific Talent," is based on the assumption that within the population available in this country there is considerable variation in creative science talent and that a major task for workers like ourselves is to develop more adequate techniques for identifying individuals with appropriate amounts of this talent. As a working approach to the problem, I believe this is sound. But, is it possible to contemplate the possibility that creative talent is being destroyed at a very rapid rate and that only a relatively small number of individuals survive as creative? A major problem for research in this field might then be to determine the forces which destroy or at least reduce creative talents so as to find ways of increasing the amount of what we term creative scientific talent. Consider a country in which the basic problem is that of securing cultural, social, and educational conditions which will provide opportunities for the development of creative scientific talent as well as other creative talents. In such a country the present homogeneity or lack of such talents may make our approach quite inappropriate. An attempt to understand such conditions in other countries may, in the long run, help us to recognize the forces in our own country which may encourage or hinder the development of the very talents we seek.

On a recent trip to India, I had an opportunity to more closely examine the cultural, social, and educational conditions of a nation which is strikingly different from our own. Although my stay was limited, the situations I observed at first hand may be related to the observations of others in such a way that generalizations are possible. I believe these conditions are rapidly changing such that the development of creative scientific talent and other talents will take place to a much greater extent in the future -- especially as these talents become more essential for the welfare of the nation and as they become more prized within the culture than was previously true. Incidentally, if my hunches about the future of India are correct, we may learn much about how social and educational forces may affect creativity by following the events in that nation very closely.

I do not intend these remarks to be regarded as disparaging of the people or the nation. I am trying to describe as objectively as possible the forces in a nation which have reduced the creativity of its people -- at least in certain directions. I attempt to do this from my understanding of creativity (largely drawn from reading the material produced by the members of this august body) as well as from my experiences with social and educational institutions.

Nor are these remarks reflections of a pessimistic view of India and its future -- on the contrary, there are strong grounds for optimism about the future of this nation -- including the development of creative talent in many areas of life. Although I am attempting to generalize about a nation of almost 400 million people, there are undoubtedly many exceptions which raise serious doubts about any attempt to generalize about national character. Nonetheless, speaking from a statistical point of view, the generalizations I am about to make represent strong enough trends to be regarded as "statistically significant," even if they are not of the character of laws or perfect relationships.

What is the evidence of the lack of creativity in one nation as compared to others? One type of evidence is provided by the personal observation of university people in our country. At present almost one half of the university students from India who go abroad come to the United States. Observations of a number of American university people are in general agreement that the Indian graduate students are exceptionally well-qualified in terms of knowledge of specific information, writing, etc. They appear to be as scholastically able as American students in the same graduate departments on tests of scholastic aptitude. However, on problems involving original and independent thinking, the Indian students appear to be much less capable than their American peers. They appear to see problems at the dissertation level which are simple and which can be attacked with familiar techniques. They become very anxious when faced with the need for untried methods, new ways of viewing phenomena, or original efforts of any magnitude. This could, of course, reflect the selection procedures which determine the students who go abroad. However, the competition for opportunities to come to the United States is very great and I am convinced that the small group of persons privileged to go abroad are among the most capable products of Indian universities.

One study in which about 300 Indian "intellectuals" were interviewed comes to similar conclusions about the lack of creative productivity of the Indian scholar and professional worker. These generalizations are reinforced by the reports of anthropologists and sociologists who have been to India. Similar observations have been reported by English university people.

Still another source of evidence on creativity is furnished by the Nobel Prize winners. In the period from 1901 to 1955 in the fields of physics, chemistry, physiology, and medicine, the numbers of awards were: Germany 41, the United States 40, the United Kingdom 32, France 15, India 1, and Japan 1. In contrast, the figures on enrollment in higher education would place the countries in the order of the United States, Japan, India, Germany, France, United Kingdom. Using college enrollment figures one might have expected India or Japan to have produced six times as many Nobel prize winners as the United Kingdom, 25 times as many as France, twice as many as Germany, and one-sixth as many as the United States. I realize the difficulties of creativeness in Asiatic countries being recognized by committees composed largely of Western scholars, but feel that outstanding work in the natural sciences has some feasibility of being recognized -- at least more than in a field like literature. One could, of course, turn these data around and ask why the United States hasn't produced 38 times as many Nobel prize winners as the United Kingdom, or 17 times as many winners as Germany. These are equally good questions and I believe they merit consideration for future work.

I have discussed this problem of creativity and originality with a number of major educational leaders in Indian universities and I find this is one of their major complaints. Their students rarely become more than capable technicians and the faculties keep searching for reasons to explain the lack of creativity. Usually, they blame the culture, the selection procedures, and the secondary education. A few are able to see relations between the learning experience provided in the university and this low level of productivity and creativity of their graduates.

The determination of the creativity of a people is a very difficult one -- if not an impossible one -- to settle on an objective basis. However, I believe all the evidence available does suggest that in Asiatic countries -- and especially in India -- there has not been the development of creative products and people commensurate with the amount of effort expended in higher education -- at least in the science areas. At a later point, I will return to evidence of other forms of creativity.

In trying to explain this lack of creativity, I have attempted to summarize some of the forces within the country which appear to me to have been weighted against the development of originality and creativity, not only in science but in other areas as well. I have grouped these forces roughly under cultural and social institutions.

Cultural Forces

Religion

About 85% of the population are Hindus who, for the most part accept Hinduism as a religion. This is not a highly organized religion with a very clear dogma. However, some generalizations may serve to describe the central core of the religion. It is a non-bookish religion which is more nearly a way of life rather than a set of practices which may be considered sacred as contrasted with secular activities. It stresses the control of the senses, the renunciation of the present life for a better life in the future, the transmigration of souls from one life to another with the law of Karma determining whether the next life is to be better or poorer than the present -- the end to be sought is Nirvana which can best be described as freedom from the endless process of living in one form or another. The religion stresses acceptance of one's fate with present time less important than either the past or the dim future. In short, it is not a religion which suggests that man can or should do much to alter the world in which he lives. Deeds of renunciation of the world are prized in themselves more than deeds involving active interaction with the world about one or successful acts of controlling or changing the natural forces around one.

Caste and sex

The Hindu society is broken down into a hierarchial arrangement of sub-societies with specific duties and functions for each caste. These sub-societies are determined by inheritance and until recently there was almost no mobility permitted. Marriage is with few exceptions within the appropriate sub-stratum and only in the subsequent lives could one presumably move from one caste to another. Caste is in many ways more powerful than race or class in this country. Acceptance of one's lot in the hierarchy has been stressed by religion, by custom, and, until recently, by law. Caste has meant that the forces around one were more powerful in determining the pattern of one's life than were the individual's own activities. Still another breakdown of the society is on the basis of sex. The male and female, especially in the village, lead quite different lives -- in many instances they live in separate dwellings. The female is regarded as lower and until recently had very few rights and prerogatives. While hierarchical societies have produced creative individuals -- in many instances, to a greater degree than democratic and non-hierarchical societies -- in few Western countries have the lines been so firmly set with so limited opportunities for unusually able persons to become mobile, or to receive training as has been true in the past in India.

Joint family

While the joint family system could be regarded as a cultural force or as a social institution, I would prefer to consider it as the former.

The joint family has been an important force for social security and stability in India. Although it is breaking up slowly, it is still a significant force in the country. In the joint family, the sons and their families live in the same dwelling with their parents. The oldest male (although occasionally the oldest female) is the supreme authority. Decisions about marriage, education, occupation, rearing of the young, and use of resources are made by the head of the family. Each member of the family is expected to accept these decisions. Self-denial and submission to the will of the elders are the major virtues.

It is evident that our picture of the scientist attempting to wrestle with the forces of nature is quite at variance with the ideal held up for the youth of India. A highly autonomous individual attempting to understand natural phenomena to satisfy his own curiosity and need for mastery may occur in India as well as in other countries. However, the cultural forces in India make such individuals the rare exceptions rather than the ideal toward which many are expected to move. Confidence in one's own capabilities (frequently found among the more productive and creative research workers), which is so sought after in our own child-rearing practices, is not the desired outcome in a society which emphasizes self-denial, submission to the will of others, and renunciation of the present life.

Social Forces

Another set of forces in a nation is represented by its political, economic, and social conditions and institutions. Although these cannot be neatly separated from the cultural values and conditions, they may be looked at one by one to determine the ways in which they reinforce the cultural forces as well as the ways in which they produce conflict with the cultural elements. In connection with the topic under consideration, I believe these forces do much to discourage or eliminate creativity.

Political

For over two centuries, India has been a colony under the rule of England. A relatively small group of Englishmen controlled the country through a set of local rulers, the Indian Civil Service, and through the educational system. The Indian who wished to secure status and economic stability had to learn English, to develop English customs, and to develop a special kind of subservience. The goal of the intellectual was usually to enter the Civil Service or to secure a position in politics or education.

Since English was the official language, he had to develop his skill in using this language as nearly perfectly as possible while at the same time using his mother tongue in the privacy of his home. He was exposed to many situations in which he was regarded as inferior for reasons of color, food habits, religious practices, type of work, dwelling, level of remuneration, etc. The conflicts between different cultures, the contrasts between extreme poverty and extreme wealth, and the comparisons between great military and political power of the English and the disorganization and weakness of the Indians were always present.

A great deal of emotion and energy was invested in this political-social area and only rare individuals were able to devote themselves fully to the attack on scientific and scholarly problems. Clearly these political and social conditions did not help individuals to develop the confidence in their own powers and capabilities which we find so frequently associated with high productivity and creativity.

Economic conditions

India is considered to be an under-developed area -- at least by the United States. The concern about five-year plans for the development of the country suggests that Indian political leaders also consider it to be under-developed. Poverty has been a problem of great magnitude. It is estimated that the great majority of Indians are rarely able to still their hunger pains. Sanitation conditions are extremely poor and disease is a problem of great magnitude. Infant mortality is especially high and the average life span of the Indian is less than 30 years.

The point of all this is that the central problem for most Indians is that of meeting bare subsistence requirements. The Indian who is successful in this area counts himself as fortunate. Much of the effort and concern of the majority of Indians, including those who have completed higher education, has been to establish some economic stability. Freedom to occupy oneself fully with abstract, theoretical, scholarly, and scientific problems has been available to only a small, well-established group of intellectuals.

Urban-rural

Over three-fourths of the Indians live in small villages primarily concerned with agrarian pursuits. These villages have minimal educational facilities and few cultural opportunities. Modern concepts of medicine and scientific notions of cause and effect in most areas of life are notably absent. The midwife delivers most babies; agricultural methods are largely dictated by custom; astrologers help many individuals reach major decisions; and superstition and old-wives tales dominate the thinking of the majority of village inhabitants.

Village life and the type of thinking and outlook of parents who have recently migrated to the city from the villages are not the type of environments in which scientific forms of thought are encouraged. One might expect that only rare individuals would free themselves from their early patterns of thought to do the kinds of observations, experiments, and conceptual types of analysis required for creativity and productivity in modern scientific research.

Education

The educational system in India was primarily created under the guidance of the English to develop civil servants. Until recently the medium of instruction was English, although the instruction was frequently offered by teachers who had relatively little facility with the language. The educational system could be characterized as a means of selecting individuals for governmental posts rather than as a means of developing the capabilities of the individual.

Much of the content of instruction had little to do with the Indian culture, problems, or needs and the student tended to look upon school learning as a necessary evil which had to be overcome if he were to gain the economic stability and status he desired.

The examinations at the end of secondary and higher education furnish the primary goal for instruction and learning. These examinations require detailed memorization of particular subject matter and emphasize highly verbal skills for recording responses to the essay questions.

A set syllabus detailing the subject matter to be sampled in the examinations furnishes the guides for secondary school and college instruction. The teachers take the students through subject matter largely through lecture methods with occasional recitation periods. The instructor rarely deviates from the syllabus since his major concern is coverage of material in order to prepare students for the examinations. In fact, the instructor who may desire to approach the subject from some other vantage point is likely to be in conflict with the students who wish him to get on with the grim business of preparing for the examinations. Understanding of ideas, abilities to do problem-solving, or genuine interest in the problems and ideas in the subject are not major goals of the instruction or learning -- and, since the examinations measure the retention of information, these other potential goals are likely to be discouraged.

The student approaches the learning by attempting to determine the most effective method of passing the examinations. He is responsive only to the instruction which is most directly related to examination passing. He will attempt to perform major feats of memorization -- committing to memory entire sections of textbooks. Most of the year prior to taking an examination is spent in preparing for the examination. Anxiety about the examination dominates the students' thinking - since 50% or more are doomed to fail. Failure is likely to mean that the students' possibilities for a professional career are cut short, with consequent lower status and less financial advantage.

It should be noted that much of the learning has relevance only for the examination. Little of the learning has any clear relation to the kind of career to which the individual aspires. This is especially true at the secondary level and is, to a large extent, also true of higher education. Passing the examination and receiving a degree or certificate are the ends to be served by learning. The government post the individual may secure does not make use of the subject matter he has learned. It is as though the school and the examinations constitute one world and the life of work or career, and the problem of the society and individual living constitute an entirely different world. However, one must fulfill the requirements of one world to be admitted to the other.

It is clear that the educational system in India rarely promotes learning in order to understand or to master ideas for their own sake. The problems to be found in a subject can only in rare cases become the central concern of the individual. Energy devoted to learning is directed toward an examination and not on the subject per se. Status -- not ideas -- is the object of attention.

It is quite evident that education under these conditions may actually be used to destroy originality, creativity, and productivity. Studies on the characteristics of the creative individual as reported by various workers at this conference stress the centrality of the individual's concern for ideas and problems in a subject field. Energy and perseverance are focused directly on the ideas and problems rather than on either the self or the aspects of the environment outside of these ideas and problems. The creative individual apparently learns to master ideas, understand, and control phenomena -- for the sake of this mastery and understanding, not for monetary, status, or other rewards only indirectly connected with the phenomena and problem.

Arising out of these cultural, social, and educational conditions one finds a large group of highly trained Indians who may be characterized as over-concerned (from our viewpoint) with security and status. Their interests in learning, in exploration of new ideas, and in creative developments are constantly tempered by realistic concerns as to the status and material gains to be secured by the individual.

The individual tends to do a great deal of stereotyped thinking in which most things are clearly labeled as good or bad, desirable or undesirable, appropriate or inappropriate. Much of the individual's thinking -- on the surface at least -- appears to be rigid, orderly, and very neat. He lives in a highly ordered life space and becomes very anxious and even aggressive when this life space is made more complex or is endangered in other ways.

It is of interest to note that much of the most creative works done by Indians falls into the fields of quantitative thinking and astronomy. I hesitate to venture an explanation for this, but I would speculate that in statistics and mathematics, orderly and logical thinking may yield good results. The emphasis on things remote in space and free from the complexities of the surrounding environment may help to explain the area of astronomy. Perhaps a simple explanation centering around the presence of vigorous and imaginative leaders in mathematics and the long tradition of research and work in astronomy may be equally appropriate.

I was also excited by the highly original drawings I found children making, their freedom in the dance, and the examples of freedom and originality in music. These are fields which the school system has touched least. It is quite possible that creativity can never be eliminated among a people and that it tends to seek avenues in which it is encouraged or at least not destroyed. I find this idea particularly attractive since it could help us understand the ways in which creativity may be channeled by the systems of rewards and ideals a society uses to perpetuate itself or to bring about major changes in itself.

What I have tried to describe is the India of a decade ago. In 1947 India achieved its independence. It is rapidly making progress on political and economic conditions. Under brilliant leaders (most of whom were trained abroad) it is rapidly creating a new ideal for India. Through the use of five year plans it is attempting to make major changes in its economy, in the distribution of income and resources, and on problems of health, sanitation, and morale.

It is not likely to make major changes, at least by plan, in the cultural area -- with the exception of laws abolishing caste and efforts to provide greater opportunities for the lower or outcast group. These laws have as yet had only minimal effect on the attitude and thinking of the population.

It is in the area of education that India is beginning to place more and more reliance for the development of leadership in practical and intellectual affairs. Some gains have already been made at the secondary level and more are expected within the next ten years. If its present plans are effective, it will be of great value to workers such as ourselves to determine whether an educational system aided by changing social patterns can produce more creative individuals when the cultural conditions still are pulling in other directions.

C--I have a comment, almost irrelevant, on what you said about people in other fields resenting concentration on creativity in science. Since I represent another field, I think at least I have an individual opinion to contribute. My feeling I believe, would be rather special and I think you are right to some extent, in so far I think as anybody understands -- has a sense of what creativity is -- he recognizes that it belongs to the unitary effort of the spirit so that there is no sense of competition in the attempt to know what creativity is. There might be a feeling of neglect on the part of society as regards the investigation of the special applications of various talents.

S--I think the point I was trying to make is that it seems to be possible through channeling, through creative efforts, to produce one kind of product versus another. There seems to have been a period in the history of India where a tremendous amount of energy was channeled into sculpture, and into the arts -- much more than seems to be true at the moment, and this seemed to be one of the heydays in Indian life. I suspect that in Russia we may find ways in which creative energies have been channeled into certain technical and scientific fields to a larger extent than in many other fields. I am really only trying to suggest that it does seem to be possible for a society -- for a nation -- to direct its creative efforts or perhaps even to destroy and block certain ones in order to enable others to occur.

C--Much of the American interest in creativity is dedicated essentially to the increase in power. People are distinctly indifferent to whether anybody wants to paint, to write, or do anything of this sort. But it is clear that if you can think creatively in science, you are of some use to the community in a direct way where increase in power and resources are the consequence desired.

S--I happen to be well acquainted with Stanley Jones, who spent fifty years in India. I was with him last week, and he said that about two or three years ago they founded the first psychological clinic. (Of course, this was with a religious background as you can understand with his being a missionary.) But it is being very well accepted by the Indian people.

C--I was struck, as you ticked off these forces one after another which seemed to be destroying or reducing creativity, by the parallel we have in our own culture of a submerged group. Many of these points are very parallel to the Negro group in this country -- caste, and the political forces, economic conditions, rural environment, and so forth, and with much the same result as far as scientific creativity, and rather interestingly on this last one about the dance and music and so forth. You also have a parallel there.

C--The same is true of a number of South American countries, and I think Mexico illustrates right now a nation which is far along -- it's in a lot of creative ferment at the moment, partly because of the incessant revolutionary tendency there. And you get tremendous transitions, for people now very prominent in the government actually began their lives born in an Indian hut and so on, so that the gap possible between the beginning and the end is very great.

C--I think that much of this ties in with this thesis of Kroeber's in his configurations of culture in which he pointed out on a somewhat broader panorama this sort of thing which you have pin-pointed very nicely for us here. I would comment, with regard to your mention of sex differentiation as a problem, that I think there are no societies known which have not had some sexual differentiation of labor and this varies a great deal. Sex and age subgroups seem to be the common groups which appear in all societies, and the degree of difference and the violence with which the difference is applied are also other major areas.

C--We were mentioning at breakfast the possibility instead of thinking of training for creativity we should think of untraining for non-creativity, which is perhaps where the heart of the problem lies.

C--I think that in all of this, it may be a good thing that maybe all these things are bad things, and maybe the kind of creativity which they are inhibiting is the best. One could make an opposite kind of argument, that is, that the introspective -- the creativity in terms of inner life may actually be greater in this sort of society and this may be a highly extroverted notion that we have of what would be the proper way of being creative.

S--Yes, although I would want to point to the large number of Indians who have sought higher education, who have sought to channel their efforts in creative areas relating to formal education. It is evident that this group of approximately a half a million students each year is concerned with entering fields where this type of creative product is sought. The other is that India is rapidly becoming "westernized," or at least more concerned with technology, with dams, with power resources, with agricultural efforts, and so on, and that these are really being hindered by some of the things I have tried to describe. For example, they have attempted to introduce more modern agricultural methods and they don't seem to be able to make as much progress as they desire. I am trying to point out that even in their attempt to eliminate the worst of poverty, they aren't able to go ahead until some of these blocks are removed.

I do not wish to say that one kind of creativity is better than another, but I am trying to say even in terms of their own goals, the forces I have discussed are hindering this desired change.

C--When you were talking about it, I thought of a Spanish philosopher, Unamuno, who when Spain was charged with much the same kind of conditions inhibiting creativity, replied grandly, "Let others invent."

S--I recognize this great danger of moving from one country to another with a particular set of values and using that as the yardstick, but I was trying to draw the yardstick from their own plans, from their own ideas, from their own aspirations.

Q--Is there no group in the Indian society that has the status to tell the rural village and get the village to believe it, say in an agricultural field?

S--I think this is rapidly coming about. I don't think it's a matter of status. It's a matter of long custom, superstition, and a whole series of these things -- notions about cause and effect which seem to be quite at variance with our own -- that dominate their thinking. The astrologer is much more significant than the psychoanalyst in India.

Q--They have not invested any group with the authority to say technology is good as yet?

S--The government group has put money and all kinds of resources into these things, which are now not quite paying off because of some of these factors.

C--That doesn't sound too unlike my recollections of Minnesota as a boy, where the individual farmer there thought he was the man to decide what to do and that's what he did until he gradually became aware of the fact that people who listened to county agents made more money and drove better cars. The county agent trained agriculturists to understand contour plowing, fancy corn and seeds, etc., and he is now a highly respected person.

C--I think a rather interesting parallel to this study of India and other cultures is the book recently published in just the last month or two, by C. D. Tuska, who is the patent lawyer at the RCA research labs in Princeton. His book is entitled "Inventors and Inventions," and uses patents as the criterion instead of Nobel Prizes, but it does quite a nice job. It discusses education, and, of course, it does the job by states -- what states have the most people going to college or getting degrees and so forth, and what is the position of women with respect to obtaining patents as the sex situation.

I think that in many of the studies of culture, of course, you find regional differences also, which fall into line with what Harmon said, although it perhaps ties in a little more education but perhaps partly culture, too. I think that this is interesting. I don't think that Tuska's book settles very much for us, but it is rather interesting. One other thing about the book which is, I think, a rather nice feature is that he has historically presented I think 42 case histories of inventions -- many of them fairly famous ones -- with something given about the conditions surrounding them.

C--I have been interested in the use of the word "training," in the talk about the Orient, with which I am quite familiar. I can't get away from the idea of animal training and human training here, because everything is documented in the Oriental culture and whether a person wants to do it or not, his stature is indicated by how well he conforms with the documented loyalties or dedications to this picked pattern. It is perhaps not until they can get away from the training idea and more into the learning -- get away from conformity to non-conformity -- that those countries will be in kind of a tight bind.

S--Unless, for the first time, the Indians seem to be getting in the notion of learning experiences as differentiated from training experiences. The problem is what is the experience the individual is going through, and what does it mean for him. But I must say that their use of the word training is, I think, characteristic.

C--Like the Japanese copy -- experts at copying, not departing from the pattern.

BASIC TRAITS IN INTELLECTUAL PERFORMANCES

J. P. Guilford
University of Southern California

S--Your chairman has made things easier by suggesting that our presentation be in the nature of reports of progress, of current activities and future plans in research. I shall do this with regard to the work of the Aptitudes Project at USC, now in its ninth year. While our work has not been aimed specifically in the direction of creative, scientific talent, it has devoted considerable attention to creativity in general and has had the scientist in mind as one type of personnel for whom creativity is very important. We have set our goal in the direction of understanding all the basic abilities and other traits that have to do with performances of an intellectual nature, believing that in the long run this is a very profitable approach.

Two years ago, as an orientation to the subject of potential contributors to creative scientific talent, I presented the outlines of a developing system of the intellectual abilities. I should like to use that system, now called the "structure of intellect," as a background for what I am going to say today. I shall therefore bring you up to date on recent conceptions of that structure, for a number of significant changes have been made. I shall then report briefly some new conclusions regarding the nature of primary abilities in the areas of fluency, flexibility, and originality, the more obviously creative abilities. I shall also report briefly concerning relationships we have investigated between selected aptitude factors and traits of motivation and temperament. Current activities of the project involve experimental and factor-analytical studies of problem solving, with two types of problems, factor analyses designed to test whether certain factors predicted by the structure of intellect can be isolated, and validation studies involving tests of fluency, flexibility, and originality.

The structure of intellect

In the classification of the known intellectual factors as presented two years ago, there were six categories of primary abilities represented. You will see from Table 1 that in the most recent organization of the factors there are five classes. (See Guilford, J. P., A Revised Structure of Intellect.) The sixth category of "symbolic factors" has been dropped, its factors having been absorbed by the remaining five, which now all represent types of mental activity.

Formerly, three of the six groups of factors were arranged in matrices of three columns each and several rows. Now all of the groups are similarly organized. The columns still represent kinds of materials with which the individual deals -- figural, structural, and conceptual. Figural materials are perceived properties of objects. Structural materials are "tokens," or code elements, such as letters or numbers.

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[1] The Aptitudes Project is conducted under Contract N60nr-23810 with the Office of Naval Research, Personnel and Training Branch. The ideas expressed herein are my own and are not necessarily shared by that agency. Associated with me in the project recently have been Paul R. Christensen, James W. Frick, and Philip R. Merrifield.

Conceptual materials are abstractions or abstract ideas. The rows of the matrices pertain to the kind of operations performed. For example, in the area of cognition, we can know elements (units), classes, relations between elements, patterns or systems, or implications. Somewhat similar row categories now apply to other groups of factors as well. It is too early to say whether a single set of row categories will apply to all groups. Complete satisfaction of the goal of a homogeneous set of row categories would involve adding rows to some of the matrices. The possibilities of new rows provide additional hypotheses to be tested concerning undiscovered factors. For example, in the evaluative category, there may be a row involving abilities for judging whether elements do or do not fit into specified categories or classes.

In the course of time an important logical distinction has become clearer. A class of divergent-thinking factors was formerly distinguished, without mention of a corresponding, convergent-thinking category. What was formerly the large productive-thinking category has been subdivided into convergent-thinking abilities and divergent-thinking abilities. Convergent thinking pertains to well structured problems for which one right answer, or a restricted number of very similar answers, is called for. Divergent thinking pertains to less structured situations, in which the individual's thinking is free to take different directions or it may pay him to think in different directions.

Two years ago, the total list included 42 intellectual factors; today there are 46. Five new factors have been added and one dropped. The factor called "speed of decision" was dropped because it seems to be more of a motivational trait than an ability. Three of the new factors have been known for some time. Auditory figural recognition appears as a mate to visual figural recognition in the cognitive list. Figural identification and structural identification appear in the first row of the evaluative list. The first of these two has long been known as "perceptual speed" and the second is a parallel factor having to do with the identification of groups of letters or numbers.

Two added factors are recent findings by the project. They were predicted by the system and they fit into formerly vacant cells. One is the factor of eduction of conceptual correlates and the other is structural redefinition.

Since the structure that you see displayed in Table 1 was published, a few other changes have been conceived. Another previously known factor seems to fit into the system. It is the factor that pertains to the rate of fluctuation of ambiguous figures. It can be regarded as a figural spontaneous flexibility. It thus seems parallel to our present factor of spontaneous flexibility, which is in the conceptual column.

Another possible change would be to eliminate from the matrix of evaluation factors the second row, which is now said to pertain to judgment of differences. In the figural column we should probably find a very large number of rather specialized abilities involved in various kinds of psychophysical judgment. Perhaps these should be regarded as perceptual abilities rather than intellectual. If we should find parallel abilities that seem to fit into the structural and conceptual columns, however, the row should be retained, regardless of the multitude of factors in the first cell.

The row categories for the area of evaluation should emphasize the criteria of evaluation. The criteria should be identity of elements for the first row, logical consistency for the present third row, and experiential consistency for the fourth row. For the last row we might identify the criterion as something like goal satisfaction. When goals have been reached there are no problems. The person who senses a problem realizes that the criterion of goal satisfaction has not been reached. This idea for the row concept means generalizing considerably beyond the limited kind of tests that define the factor of sensitivity to problems at present, but it is a good hypothesis to try out.

I suggested to some of you this morning that we are tolerating the idea that there should be a fourth column in all these matrices -- at least in some of them -- devoted to material that can be called "psychological," or "behavioral," or "social." Take the cognitive category, for example. Cognition of psychological material would mean cognizing the behavior of other people -- their thoughts, their feelings, their emotions, their attitudes, and so on. This has generally come under the heading of "empathy" in current research. I think that we might predict that there are abilities to perceive elements of this kind, to cognize relations between elements, to cognize patterns, and to cognize implications, which would play a role in predictions of behavior.

As Dr. Bloom was speaking, it occurred to me concerning the general category of cognition, that the Indian students restrict themselves pretty much to this area of functioning. They do not venture very far into the area of production -- at least into divergent-thinking production.

Fluency factors

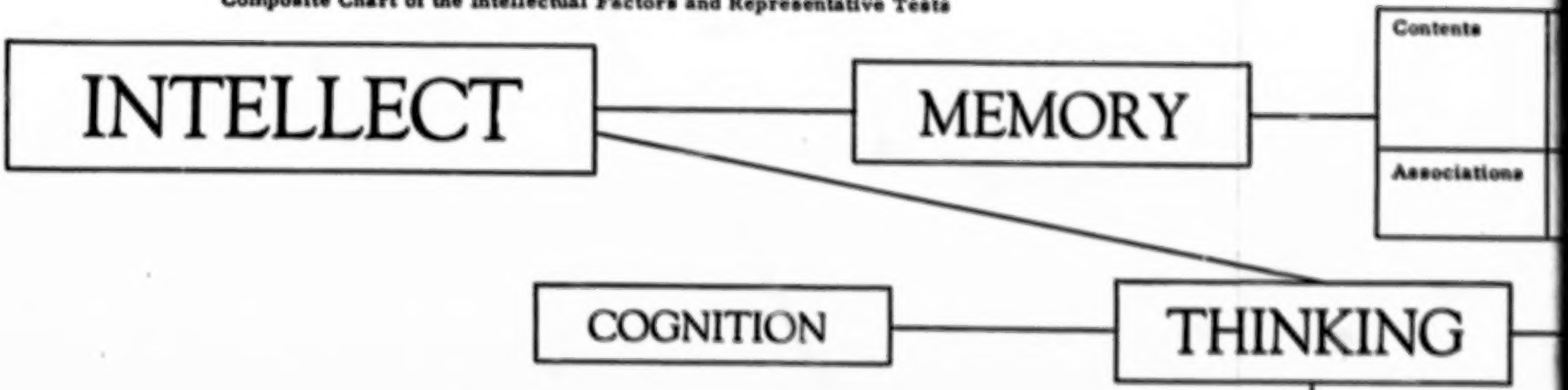
In our recent study of verbal-fluency factors, we emphasized minor, systematic variations in our tests of the different fluency factors, in an attempt to determine the optimal conditions for measuring each ability. (See Guilford, J. P., & Christensen, P. R. A Factor-analytic Study of Verbal Fluency.) This procedure is a possible refinement in a factorial-analysis study when we have much prior information regarding factors.

For example, among tests of the factor of word fluency, we varied the degree of restriction placed upon the task. In the test with least restriction the instruction was merely to "list words rapidly." In three other tests, every word listed must contain one, two, or three specified letters, respectively. As it turned out, the test form without any restriction proved to be almost worthless as a test of word fluency. The other three were all fairly good measures, with the three-letter restriction being possibly a bit inferior to the other two.

A typical test of associational fluency requires the examinee to give a list of words that means about the same as a stated word, such as the word "happy." We were interested in knowing whether responses given early vs. late in the time of working on an item would emphasize this factor more. From an experiment on tests of ideational fluency we had found that later responses indicate more originality than earlier responses. We accordingly obtained scores for associational fluency from the first half-minute of work and from each minute thereafter up to five minutes.

TABLE 1

Composite Chart of the Intellectual Factors and Representative Tests



	Figural	Structural	Conceptual
Fundaments (units)	Visual figural recognition Street Gestalt Completion Mutilated Words Auditory figural recognition Haphazard Speech Illogical Groupings		Verbal comprehension Vocabulary Reading Comprehension
Classes	Figural classification Figure Classification Picture Classification		Conceptual classification Word Classification Verbal Classification
Relations	Eduction of figural relations Figure Analogies Figure Matrix	Eduction of structural relations Seeing Trends II Correlate Completion II	Eduction of conceptual relations Verbal Analogies Word Matrix
Patterns or Systems	Spatial orientation G-Z Spatial Orientation Flags, Figures, Cards	Eduction of structural patterns Circle Reasoning Letter Triangle	General reasoning Arithmetic Reasoning Ship Destination
Implications	Perceptual foresight Competitive Planning Route Planning		Conceptual foresight Pertinent Questions Alternate Methods Penetration Social Institutions Similarities

Identity of units
Differential
Logical
Experiential
Problematical

PRODUCTION

Convergent

Names	Object naming Form Naming Color Naming		Concept naming Picture-Group Naming Word-Group Naming
Correlates		Eduction of structural correlates Correlate Completion II Figure Analogies Completion	Eduction of conceptual correlates Vocabulary Completion Inventive Opposites
Orders			Ordering Picture Arrangement Sentence Order
Transformations	Visualization G-Z Spatial Visualization Punched Holes	Structural redefinition Camouflaged Words Hidden Figures	Conceptual redefinition Gestalt Transformation Object Synthesis
Unique conclusions	Symbol substitution Sign Changes Form Reasoning	Numerical facility Numerical Operations	

Words
Ideas
Expressions
Adaptive shifts
Non-adaptive shifts
Novel responses
Details

* Appears at present to be one factor. Future results may show it to be two.

MORY

	Figural	Structural	Conceptual
Contents	Visual memory Reproduction of Designs Map Memory Auditory memory Musical Memory Rhythm	Memory span Letter Span Digit Span	Memory for ideas Memory for Ideas Limericks
Associations		Rote memory Word-Number Color-Word	Meaningful memory Sentence Completion Related Words

THINKING

EVALUATION

	Figural	Structural	Conceptual
Identity of units	Figural identification G-Z Perceptual Speed Identical Forms	Structural identification Scattered X's Identical Numbers	
Differential	Length estimation Ratio Estimation Figure Estimation		
Logical		Symbol manipulation Symbol Manipulation Sign Changes II	Logical evaluation Logical Reasoning Puzzles
Experiential			Experiential evaluation Unusual Details Social Situations Judgment Practical Judgment Practical Estimation
Problem-atical			Sensitivity to problems Seeing Problems Seeing Deficiencies

Conceptual
mpı ...ension ry Comprehension
l classification assification Classification
f conceptual nalogies trix
asoning ic Reasoning ination
l foresight Questions Methods n stitutions ies

PRODUCTION

ming roup Naming up Naming
f conceptual e y Completion Opposites
rrangement Order
redefinition ansformation thesis

Divergent

Words		Word fluency Prefixes Word Listing I	Associational fluency Controlled Associations II Simile Insertions
Ideas			Ideational fluency Thing Listing Brick Uses (fluency)
Expressions			Expressional fluency Four-Word Combinations FL Simile Interpretation
Adaptive shifts	Figural adaptive flexibility Hidden Pictures Gottschaldt Figures A	Structural adaptive flexibility Match Problems Planning Air Maneuvers	
Non-adaptive shifts			Spontaneous flexibility Brick Uses (flexibility) Unusual Uses
Novel responses			Originality Plot Titles (cleverness) Symbol Production
Details	Elaboration* Planning Elaboration Figure Production		Elaboration* Planning Elaboration Figure Production

Our analysis showed that within the five-minute working period the scores were about equally good for measuring this factor.

An incidental finding of some importance was the distinction brought out between associational fluency and the new factor of eduction of conceptual correlates. The latter is an ability to give a word response when another word and a relation are provided. The two factors are indicated by a slight change of testing conditions. Both involve giving word responses when another word and a relation are provided. But a measure of associational fluency emphasizes a number of different responses to each of a few items whereas a measure of eduction of conceptual correlates emphasizes a single response to each of a large number of items. The two are parallel and alike except for the convergent-divergent distinction.

Ideational fluency continues to be regarded as the ability to produce rapidly a number of alternative ideas where quality is of no consequence but relevance is. Our results show that a relatively low degree of restriction in the task is desirable, but not too low. Three levels of restriction were introduced in three similar tests, involving the naming of objects where one, two, or three class properties were specified. Thus, examinees might be asked to name objects that are solid, to satisfy only one property; to name objects that are both solid and manufactured, to satisfy two specified properties; and to name objects that are solid, manufactured, and black, to satisfy three specified properties. The case with two specified properties proved to be somewhat better than that with only one, and much better than that with three for the purposes of detecting individual differences in ideational fluency.

The factor of expressional fluency, as we find it, is an ability to put words into connected discourse, i.e., the formation of sentences or phrases. The best tests of it require examinees to produce rapidly either phrases or sentences containing two words or four words. Another good test requires the writing of sentences, each of which contains four specified words. It is not measured by tests that require the completion of similes. Such tests instead measure either originality or associational fluency. It is not measured by tests requiring the restatement of the same idea, as in writing a headline in varied ways. It is not measured by a test requiring the writing of a short story that incorporates somewhere in it ten given words. Such a test measures originality. In such a way, experimental variations help to tell us what a factor is not like as well as what it is like. As of now, our conception of expressional fluency restricts it very much to the dealing with sentence structure. From this point of view it might be more appropriately placed in the structural column of the matrix rather than in the conceptual column.

Flexibility factors

One of the major objectives of our recent study of flexibility of thinking was to relate the flexibility factors to the concept of rigidity. (See Guilford et al., A Factor Analytic Study of Flexibility in Thinking.) We did not tolerate seriously the idea that rigidity is a single, universal, human trait; we hypothesized instead, that there are at least two types of rigidity in thinking -- perseveration and persistence -- qualities that are opposite to our primary qualities of spontaneous flexibility and adaptive flexibility, respectively. We proceeded to test this hypothesis, tolerating different conceptions of all four qualities, and the possibility of as many as four factors, two of rigidity as well as two of flexibility.

Our results definitely point to the existence of two factors, with the bipolarities as hypothesized. We arrived at a revised definition of spontaneous flexibility which describes it as the ability or disposition to produce a diversity of ideas, with freedom from inertia and restraints. Our results indicate several properties that the factor evidently does not possess. It does not pertain to shifts away from the obvious or the trite. Tests of this tendency went in the direction of originality, as they logically should. Spontaneous flexibility is freedom from inertia, but this does not necessarily mean a preference for shifting from one theme to another over-elaboration of the same theme. Tests of this type went in the direction of the factor of verbal comprehension. One example is a test called Chain Associations, in which the examinee just listed words, each one associated with the one before. The score for flexibility vs. perseveration was the number of changes of topic or theme.

The new conception of adaptive flexibility stresses the idea of restructuring of problems or of other conceptions and avoidance of persistence of thinking in maladaptive directions. Our results did not support G. A. Ferguson's hypothesis. (See Oliver, J. A. & Ferguson, G. A., and also Scheier, I. H. & Ferguson, G. A.) According to Ferguson, rigidity is an exhibition of negative transfer effects. Rigidity means that learned habits are used persistently in the wrong places. We had two tests that might be described as involving the interfering effects of learned associations -- Circle Square II and Circle Square Triangle. Neither was found to be related to adaptive flexibility. As a test of the maladaptive application of a wrong method, we used an adaptation of the Luchins' Water Jar test. It proved to be much more strongly related to the factors of general reasoning and logical evaluation than to adaptive flexibility. There is some doubt regarding the interpretation of this result, since our special study of this test revealed that the Water Jar test fails generally to induce an effective, maladaptive set. As a measure involving the possible maladaptive functioning of familiar meanings we used a test called Object Synthesis, in each item of which the examinee combines two objects to produce something with a new function or use. This test was found related to originality rather than to adaptive flexibility.[2] The restructuring involved in performances in which adaptive flexibility is important seems, therefore, to be something other than freedom from interference from familiar meanings and freedom from interfering associations, if our few tests satisfactorily represented those conditions. Whether it involves freedom from interfering sets or methods is an open question. It seems unlikely that the factor represents a general freedom from negative transfer effects.

Relations of selected aptitude traits to non-aptitude traits

There were several reasons for believing it would be fruitful to consider possible relationships between traits of motivation and temperament and intellectual traits of aptitude. A few studies in the past have suggested that such relationships may exist, particularly with factors of fluency, flexibility, and originality. (See Adkins, D. C. & Kuder, G. F.; Denton, J. C. & Taylor, C. W.; Drevdahl, J. E.; Pemberton, C. L.; Scheier, I. H. & Ferguson, G. A.; Studman, L. G.; and Welch, L., Diethelm, C., & Long, L.) So far as flexibility factors are concerned, this question goes beyond their relationships to perseveration and persistence of thinking, since we have shown the latter to be essentially opposite poles of two forms of thinking flexibility. If there are three factors of spontaneous flexibility and three of adaptive flexibility, there are presumably three qualities of rigidity to go with each kind of flexibility. Our interest here is a more general one, including relationships involving correlations other than minus one.

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[2] This fact was one of the reasons for suggesting in the report by Guilford et al. on flexibility of thinking that the factor originality might be regarded as a conceptual adaptive flexibility and be placed in the same row with the present adaptive flexibility.

In previous discussions it has been suggested that the factor of originality might be a temperamental or motivational trait of unconventionality or non-conformity, a resistance against repeating what other individuals do. (See Guilford, J. P., The Structure of Intellect.) Spontaneous flexibility, it was suggested, is a resistance against repeating one's self. We have obtained some information regarding these possible interpretations or relationships and many others.

There is the very general problem of possible relationships between interest factors and aptitude factors. Traditionally, not much correlation has been found between somewhat parallel interests and aptitudes. In most cases the studies have not been made in terms of factors of interest and factors of aptitude. Theoretically, such relationships should exist. There is an implication from psychoanalytic theory that abilities should develop in accordance with dynamic, which is to say motivational, which is to say interest, variables. Learning theory that stresses the concept of effect would also lead one to expect some relationships to be developed between corresponding interests and aptitudes.

We have a large number of thinking-aptitude factors at our disposal for investigation purposes in connection with this problem. From previous work on non-aptitude primary traits we have at least three proposed factors of interest in different types of thinking. One is an interest in logical thinking or rigorous thinking, such as mathematical thinking, problem solving, and puzzle solving. A second is an interest in meditative or reflective thinking. A third factor, which needs some verification, has been identified as interest in autistic thinking. This involves a self-enhancing, daydreaming type of thinking. (See Guilford, J. P., et al., A Factor Analysis Study of Human Interests.) The liking for the rigorous type of thinking has been shown to have strong relationship to the factor of interest in science. Meditative thinking seems more related to less rigorous types of philosophizing, but might play some role in connection with scientific curiosity and in scientific theorizing where some freedom from rigor is tolerated. Autistic thinking has no conceivable relationship to a scientist's operations.

Reflecting upon the varieties of thinking-aptitude factors, we thought it desirable to consider hypotheses regarding other possible primary interests in the area of thinking. We thought first of the hypothesized trait called "intolerance of ambiguity," so prominent in connection with the studies of the "authoritarian personality." We hypothesized a similar, but possibly somewhat independent disposition that might be called "decisiveness." We also hypothesized traits involving preferences for goal-directed thinking, fanciful thinking, divergent thinking (both spontaneous and adaptive), dilettantism (superficial, shifty thinking), and whimsical thinking (thinking with surprising twists and turns). We also sought to determine whether a factor of persistence could be demonstrated by methods other than behavior tests and whether it would be related negatively to adaptive flexibility.

The possible relations of these hypothetical traits to different thinking aptitudes are fairly obvious and I cannot take time here to elaborate upon them. Some other previously known non-aptitude factors that we believed to be possibly related to factors of creative thinking might be mentioned briefly. General activity might be related positively to all of the fluency factors. Positively related to one or more of the factors of ideational fluency, expressional fluency, originality, and spontaneous flexibility might be the factors: need for freedom, need for variety, impulsiveness, need for adventure (risk-taking), and interest in aesthetic expression. Negatively related to one or more of these same factors might be: cultural conformity (which stresses moral values), need for discipline, and meticulousness (need for order).

At the present time, the only available method of assessing temperamental and motivational traits on a comprehensive scale in human subjects for research purposes is the inventory method. Previously known factors in those domains had been determined by the use of inventory scores. Our factor analysis that was aimed at the investigation of new, hypothesized factors in the area of thinking interests was based upon inventory-score variables. The findings in terms of factors and their relations to aptitude factors must therefore be interpreted with this kind of data in mind. We are dealing with information derived from individuals' views of themselves as expressed in responses to specific questions concerning their preferences for many kinds of thinking activities.

Our analysis indicates several new types of interest in the field of thinking, some of which seem parallel to aspects of the thinking categories in the structure of intellect. A factor of interest in convergent thinking was found, indicated by expressions of preferences for goal-directed thinking and for decisiveness in one's self and in others. A factor of interest in divergent thinking is indicated by items designed to measure interest in divergent thinking and also by items designed to measure dilettantism or shifty thinking. The hypothesis of a trait of intolerance of ambiguity receives support in the form of a factor that is indicated by a score to measure what we called black-white thinking and also a score for feeling of need for definiteness. A fourth factor was not so easy to interpret, but it appears to represent an appreciation of originality or of creativity in general. It might possibly be the previously known factor of aesthetic appreciation or the factor of aesthetic expression, we do not know. It is indicated by scores for liking for whimsical thinking and fanciful thinking, and bears some relation to items on interest in aesthetic expression.

Our main objective concerned the amount of correlation between certain thinking-aptitude factors on the one hand and certain non-aptitude factors on the other, including those pertaining to thinking interests as well as others. In order to reach conclusions on these intercorrelations, we derived measures of the factors by using composite scores for factors of both kinds wherever possible. Because our samples of subjects were very large, being approximately 200 in some instances, 400 in others, and nearly 600 in still others, rather small coefficients of correlation can be significant. The subjects in three samples of about 200 each were Coast Guard Cadets, Air Force Air

Cadets, and Naval Air Cadets who were just entering training.

The intercorrelations are generally very low, the highest being about .30. I shall mention only selected instances of correlations, all of which are significant beyond the .05 level, in connection with some of the thinking factors. These correlations are mostly in the range from .15 to .25.

It appears that those who are higher in the factor of associational fluency are inclined to be more adventurous (risk-taking) and to be more tolerant of ambiguity. For either reason, apparently, a person may be willing to accept and to list synonyms less exactly related to the stimulus word given in a test of this factor. That is one way of obtaining a higher score. We should consider alternative hypotheses in interpreting these results. One conclusion would be that the factor of associational fluency is slightly related to the factors of intolerance of ambiguity and need for adventure. But another would be that tests of associational fluency measure those two factors in addition to that aptitude factor, the factors as such being unrelated. The same alternative interpretations must be considered in connection with other correlations to be mentioned.

Scores for ideational fluency tend to be higher if the person is less neurotic and if he is more ascendant, self-confident, and impulsive, and if he appreciates creativity and rigorous thinking. Scores of expressional fluency tend to be higher if the person is impulsive and also if he appreciates creativity and reflective thinking. Scores for spontaneous flexibility tend to be higher for the person who is interested in reflective thinking. Greater originality is shown in test scores if the person has appreciation for creativity and interest in reflective thinking and in divergent thinking; if he is self-confident and tolerant of ambiguity; but if he is not meticulous or does not feel a strong need for discipline.

Outside the more obviously creative abilities we find that a person with higher scores on general reasoning tends to like convergent thinking and rigorous thinking, and to have a low need for cultural conformity. He is not only ready to tackle problems because he structures them easily, but also enjoys solving them. The person who is strong on logical evaluation also likes rigorous thinking and reflective thinking.

Incidentally, several non-aptitude factors were found with some relations to scores for the factor of verbal comprehension. Since this factor is the dominant one in verbal-intelligence tests, these results are of special interest. They indicate that the more verbally intelligent person is inclined to appreciate creativity and to tolerate ambiguity, but to be less meticulous, less active, and less inclined to cultural conformity, to autistic thinking, and to need for discipline.

It is of interest to note where expected relationships were not found. Scores for the trait of general activity had zero correlations with all fluency-factor scores. Since the activity implied in this trait score is overt, this finding should not be too surprising. Scores for cultural conformity had zero correlations with scores for both originality and spontaneous flexibility. Need for adventure (risk-taking) had zero correlations with scores for both ideational fluency and originality. This is interesting in connection with the hypothesis that McClelland presented to this group two years ago. It may be that the scientist who is effectively creative is inclined to take risks, as

McClelland proposed, yet a person can apparently be a rapid producer of ideas and can be original without having a need for taking risks or obtaining enjoyment from taking risks. It must be that the risks of the scientist are something very different from those involved in the factor of need for adventure. In the latter case risks to personal safety and personal property are emphasized. The scientist, on the other hand, runs the risk of being wrong and personal danger is usually not involved. The kind of adventure of the scientist is usually different from that exhibited in travel or geographical exploration.

Scores for need for variety correlated zero with scores for both ideational fluency and originality, and just missed a significant correlation with scores for spontaneous flexibility. This finding agrees only suggestively with the definition of the latter factor as the ability to produce a diversity of ideas. The scores for persistence did not correlate negatively as might have been expected with scores for adaptive flexibility.

Q--Isn't there such a thing as adaptive persistence?

S--In connection with adaptive flexibility, it is persistence in pursuit of a goal.

The conclusion must be that the kind of persistence indicated by our inventory score is completely different from persistence in direction of thinking. Scores for need for discipline were expected to correlate negatively with both originality or spontaneous flexibility. They correlated zero with scores for spontaneous flexibility but -.17 with originality, which was significant at the .01 level. Scores for need for freedom correlated zero with both originality and ideational fluency, where positive correlations might have been expected. (See Guilford, J. P., et al., The Relations of Creative-thinking Aptitudes to Non-aptitude Personality Traits.)

From all these results we may conclude that on the whole, relationships between aptitude factors and non-aptitude factors, where any are indicated at all, are generally very small. Although the low correlations may be due in large part to the quite different methods of assessing the traits -- inventory scores in the one case and behavior-test scores in the other -- they are not encouraging to the expectation that we shall ever find strong relationships, even with better variables. There is considerable reason, therefore, to describe persons in terms of both aptitude and non-aptitude variables. This may be of some practical importance, for if both kinds of traits are found to be related to practical criteria of success in science or elsewhere, the two sources of information would contribute more or less independently to predictions of performance.

The results and conclusions just considered pertain to relationships within a population of individuals. We should also consider relationships within individuals. Such relationships pertain to populations of traits rather than populations of persons and they call for ipsative measurements rather than normative measurements. It is quite possible that correlations between corresponding interests and aptitudes would be higher within persons than they seem to be within populations of persons.

Of incidental interest is the general conclusion regarding the suspected non-aptitude character of either originality or spontaneous flexibility. Although the latter was found slightly related to need for variety, it is obviously much more than that. Originality cannot be accounted for as a need for freedom or as a freedom from cultural conformity. If original people, as shown by tests, are unconventional, it is primarily a limited unconventionality in ways of thinking not in a very general sense that shows up in personal conduct. If certain people in the arts, for example, seem inclined toward unconventionality of conduct, it is perhaps because in those individuals unconventionality has become more widely generalized. In other words, general unconventionality does not seem to be essential for creativity. This conclusion would be supported by common observations of creative scientists.

Basic studies in process

Much of our current interest in the Aptitudes Project is in the relation of thinking factors to problem solving. We are proceeding under a general assumption that the demand upon human resources in the form of intellectual abilities differs from one kind of problem to another. There is no single problem-solving ability and there is probably no single pattern of abilities that constitute a standard and universal ability to solve problems. From the factor-analysis point of view, the problem is to attempt to specify what abilities are of importance in different types of problems.

A study under the direct supervision of Philip R. Merrifield emphasizes problems of a certain type. Predictions are made as to the role of the various factors in solving this type of problem and a factor analysis will be carried out to test those predictions. We are making a similar study in conjunction with Dr. James F. Craine, who has designed a problem of a quite different type involving the use of equipment.

The other main aspect of our work is concerned with the undiscovered factors implied by the vacant cells in the structure of intellect. Most of these vacancies are in the figural and structural columns. New tests are being prepared for the hypothesized factors, by analogy to tests of parallel, known factors. Analyses are planned in both the figural and structural areas. The structural area is believed to be of practical importance because much mathematical thinking seems to belong in this category, as do many of the operations with language in general. The figural area is believed to be important for the creative artist of different kinds -- in graphic arts, in music, and in dramatic arts -- as well as for the engineer.

Validation studies

Two major validation studies are under way. One involves the verbal-fluency factors in relation to writing. All freshmen entering USC last year were given tests of these factors. We have at our disposal several themes written in class by each student as well as instructor's marks to use as criteria. Themes are being scored as objectively as possible in several ways. We shall follow some of the students into courses of creative writing later.

The other validation study involves tests of several factors, which were administered to all students entering the School of Engineering at USC. This is a continuing study for which we shall expect to have evidence of creative performances or promise thereof, both later in school and after.

Q--I have one question about the factors that you speak of, the temperamental-personality factors and so on. There is no external validity evidence for those measures. You have made a general statement that only inventory measures are presently available.

S--This is true for large-group testing and for most of the factors.

C--I was thinking especially of the conformity variable where you are able to gather data through an actual performance test where the persons are placed in the situations.

S--Is it known in that case what proportion of the variance is actually conformity variance?

C--I am sure there is variance in it other than conformity, but on the face of it the situation is so defined that the individual is under some degree of pressure to conform to a false group consensus.

S--Until that test had been factor analyzed, I wouldn't feel like putting it in as a reference test.

Q--If we take for granted that the personality tests are valid -- or will be substantiated to be valid -- and that your structure here holds up and tests are not too much changed in the future, and the conclusion holds up that a great many of these personality traits are not related to aptitudes, then we think both of them -- aptitudes and personality -- are important for creative scientists. This is a good type of finding.

S--It is very favorable for good prediction, when you have both of these almost independent sources for prediction purposes.

C--I stand in awe of your tremendous amount of work. I remember meeting you about nine or ten years ago when you began following this. But the problem I get into when I look at this material is your use of the correlation coefficient as your indicator of what it is you have. However, as you begin to talk about the follow-up validation studies you are going to do, you may be going in a different direction. It seems to me that life would be too simple if we could relate one ability to a personality trait or some other trait. What I would like to ask is whether you have done much in this research in which you are trying to find if there is a pattern of things. Are you doing, or are you going to do analyses in which you will be trying to find how a cluster of characteristics may be associated with a particular objective index on the individual? I would agree that when we get into personality we are working with a different kind of thing in terms of objectivity, in terms of performance, and in terms of the individual's motivation. But I am still trying to look for ways in which these can be interrelated patterns.

S--There are several answers, since your questions involve several points. First, you have to remember that the factor analysis model is simply a mathematical construct to try to describe the nature of personal traits, and each one of these factors is one of these abstract things that comes out. We think that they are real because they come out of empirical evidence that we have, namely, correlational evidence.

This does not mean that each factor operates separately and independently in the individual. Obviously as I have said in connection with problem solving, there is a combination of them utilized or involved in a certain kind of problem solving. That is one instance where we are trying to predict a pattern and find whether the pattern does exist as we predicted. Other patterns might be found in a more general way in the form of syndromes, which is perhaps a word that applies to what you are thinking about. This would arrive out of the interrelationships of the factors. Although we use orthogonal rotations, we do not fool ourselves into believing that the factors are independent in the population. We are giving some thought to the general picture of intercorrelation of the factors in the population we are using. We do not have enough information yet to estimate the correlation between all factors, but we are trying to build this up and come out with a general picture of the intercorrelations of the factors. From this we would hope to construct syndromes that you referred to.

Q--Does this mean that you would also begin to use inverse factor techniques or correlation techniques?

S--Possibly yes.

Q--I mean would you correlate people rather than scores?

S--No, we have not thought of that approach in this connection yet. Do you mean the kind that would include non-aptitude as well as aptitude factors? This would be important, too.

C--From my experience, when you use these types of things to predict some criterion you might find that there will be a relation in the lower half of the distribution and not in the upper half. I presume you will be looking at that when you work with operational criteria.

Q--I wondered if you had found tests that proved to be better measures of originality in the last few years than you had earlier, or if the tests you originally came out with pretty well held firm?

S--Those original tests have held up very well, except for the Quick Response test which has "washed out" as a measure of originality.

Q--I think it is of great interest to find that as people continue to respond to a test, the nature of the test might change toward an originality test, for example, as you indicated in ideational fluency.

S--Do you mean the same people?

C--Yes, you indicated the later responses in ideational fluency were of higher quality and more original. What puzzles me is that I heard tell once of a person who decided to challenge a manic to see if he could keep talking as long as the manic. He practiced for quite a while, but then when they had the competition, after five minutes he ran dry, but the manic just kept going.

C--That's somewhat related to the thing that has been bothering me for quite a little while. You mentioned when you spoke about autistic thinking and daydreaming that there's no relation to the scientific and the creative scientists. I've been thinking along the lines of spurious vs. genuine or real creativity -- that is, the crackpot inventor as compared to the creative scientist. And it seems that the creative scientist respects the heritage, the tradition, the framework of science, whereas the crackpot will ignore it completely. Now this daydreaming, it seems to me, bears somewhat the same relation to incubation. I think there is little question but what the incubation period is where the real visualization, the real insight comes, and I wish you would comment just a little about that in a positive way. The wild daydreaming, ignoring the framework I can agree, is not relevant, but the incubation period is something positive.

S--Well, we have to remember that there are different kinds of daydreaming. It isn't all one kind of thing -- daydreaming of the autistic-thinking factor would be a person imagining himself to be returning home as a hero, leading a parade, etc., and that's not the kind of thing a scientist indulges in, is it, in his incubation? Incubation might be a day-dreaming sort of thing, but not that sort of thing.

Q--On this very point I wondered if you had any further elaboration of your description of artistic thinking, since daydreaming kind of thinking is pretty much irrelevant to the production of useful artistic constructs. I wondered if you had enriched this notion in any other way.

S--Well, it occurs to me now that maybe the daydreaming you are talking about in connection with incubation would be a matter of a spontaneous flexibility.

Q--Isn't there a confusion of terms? One of you is saying "artistic," and the other one is saying "autistic?"

S--No, are you saying artistic?

Q--I simply misheard then. (Laughter.) The artistic is completely irrelevant in your findings regarding autistic thinking then?

S--Yes.

C--That's exactly what one would expect in the field of art, too. The aggrandizement of the ego is irrelevant to the construction of artistic significance, that one has to look aside from one's egoistic preoccupation. The production of anything useful involves a transcendance of self, though a lot of so-called artistic products are autistic too.

S--Yes, wouldn't you find the art work of a schizophrenic artistic perhaps?

C--And the art work of a lot of people who will never get anywhere because they are not interested in the creation of significance, but in the creation of a larger chest or head measurement.

Q--I wonder how worried one ought to be about the lack of external validity evidence for the factor scales measuring interest and temperamental personality factors? I grant you that I, too, would like to know what the factorial structure of the conformity test is.

S--I am concerned about this question and I would like to have some other kind of supporting evidence. I do not know what it could be without considerable work in development of things we do not have already.

C--I would comment that it is nice to get these factor patterns, because as others come along with criterion situations they can use these tests of known factorial content and select the more relevant ones for validation against the criteria.

Q--I would like to ask one more question about the patterns. Besides the curved correlations between individual tests and criteria we have run into things -- you've probably heard about them -- where there is a relationship between two tests, where if one test is high the other does not mean a thing, but if one is low, then the other one is very predictive. Have you thought of ways of handling this....we call it moderator variables?

S--We have not found it.

C--I would think you might when you start to deal with external criteria.

C--Another question pertains to the freshmen that you have been testing. It was interesting to note that you expected to lose students, but I was wondering if you have tried to follow up on the students you lose to try to find out what the university was not doing, perhaps, for some of them that had promise.

S--That's a good idea. We had not thought of it.

C--To see if they can write as well whether they take that course or not? (Laughter.)

Q--Is it possible that some who felt their own creativity would avoid the creative writing courses?

C--I think there might be a significant number of students of that kind. It is just a speculation.

C--Persistence would indicate a lack of adaptive flexibility in this case. (Laughter.)

C--A phenomenon happened to occur at Osborn's conference which might be of interest in connection with your point that the pertinent resources of the organism differ with the type of problem. I saw somebody get into an awful mess in which their ideational fluency completely bogged down when the problem was inadequately set up. It became a three-pronged problem with different factors underneath -- different variables -- and when the problem was straightened out and reduced to a small enough area so they could concentrate on it, the creativity with respect to ideational fluency immediately accelerated in a tremendous manner. It was very significant. I think that the setting up of the problem seemed to be the most critical factor. It seemed to be more effective than anything else, no matter whether they brainstormed or how else they worked at it.

S--It could well be, and the setting up of the problem involves the factor of general reasoning, I think.

C--I want to comment at some length on the relation between interest and aptitudes but I will postpone that because it will be part of my own presentation later. I have a hunch I know I'm going to find higher correlations.

S--There's another approach to this, and that is intra-individual correlation. That was done by Wesley, Corey, and Stewart. They found correlations averaging about .46 within individuals between Kuder scores and other scores, whereas by using the ordinary, normative scores, the correlations averaged about .30.

C--We have been doing much the same and find very high correlations when we are about to rule out what might be called the general ability in the Primary Mental Abilities when correlating against the Kuder Preference.

S--Another thing we might do in the factorial approach would be to find syndromes of interest factors, and correlate them with syndromes of aptitude factors.

C--You'll never run out of things to do -- I can see that.

C--I still would return to the question of whether we can, with statistics, develop techniques other than the correlation ones to look for these relationships. I realize it's a very vague question, but I'm still concerned with our preoccupation with covariance.

S--If I understand correctly, you are saying that the model is not adequate for what you want to do, and maybe we do need some more highly developed models to take care of what you are talking about. But the correlation coefficient would probably remain your basic information for indicating concomitances in behavior.

C--I was impressed with the greater amount of white, unfilled space in the blocks on the right-hand side, under divergent thinking, than was on the left-hand side of the chart, and also that the right-hand side was most filled in the conceptual column.

S--The answer is that we have just not explored those divergent, figural, and structural areas as we have the verbal areas. We are going to initiate later a study which will emphasize divergent thinking in tests in which we have figural material and structural material, with the expectation that these blank spaces will be filled when we use those types of material in divergent-thinking type of items. The reason we have found more convergent than divergent factors is also a matter of the areas that have been explored. Psychological testing has aimed at economical forms of tests with multiple-choice answers and that is likely to mean convergent thinking. To date we are better acquainted with convergent thinking, in general, than with divergent thinking, which is a new concept. To measure divergent thinking we have to resort most of the time to open-end items, not multiple-choice items.

C--This is the area in which we have been mainly working in our communication abilities research but we have not yet tried to fit our communication factors into Guilford's pattern for divergent thinking.

THE DEVELOPMENT OF A CRITERION OF SCIENTIFIC COMPETENCE

Lindsey R. Harmon
National Research Council

S--I am grateful to the Taylors, Don and Cal, for speaking first. I am grateful to Cal for reporting the first Irish coefficients for the validity of the Grade Point Average, and to Don for reporting research in progress, with the computations still incomplete at deadline. Since I'm going to have to do both of these things, it is nice to have such illustrious predecessors.

Two years ago, this conference struggled through three sessions on the criterion problem, and a committee spent several hours in two more sessions on that subject. The end result was a schema for a criterion of scientific creativity which worked backwards from an "ultimate criterion" of an individual's total life production of scientific creations to earlier substitute criteria which might come soon enough in the person's life to serve as a practical means for the validation of predictors.

I will not review in detail the previous conference's work on this subject, but will note just two features that are particularly pertinent for the data that I am to report. One of these is the fact that, in the 1955 schema, after the initial subjective process of defining an ultimate criterion, the procedures were to be rigorously objective and statistical. We seek early correlates of the ultimate criterion and define our measure of success in achieving these earlier substitute criteria in terms of the size of the multiple correlation coefficient for the prediction of the ultimate criterion. The second point is that as we regress from the ultimate criterion to the earlier and more economical correlates, we move over gradually from criterion-type measures to predictor-type measures. This movement may procede through measures which we designate by such terms as "reference variables," which we do not think of as being strictly either criteria or predictors, but only as landmarks to tell us where we are going.

These two features are present in my report. We have tried to be statistically rigorous. We have employed objective criterion elements, reference variables, and predictors. In no other way have we been able to employ the 1955 schema. That is, we could not start from some ultimate criterion and work backwards. We were in no position to do this because we were working with younger scientists, who are just at the beginning of their careers, and we are seeking the first glimmerings of criterion variables in order to have some measure against which to validate our predictors.

Let me give you a little background of this situation. Shortly after World War II, the Atomic Energy Commission felt that it should do something to help replenish the scientific manpower pool which its manifold operations were draining. It sponsored a fellowship program in the natural sciences as one means to this end. This fellowship program was taken over by the National Science Foundation in 1952, and has subsequently operated in much the same fashion, as far as selction techniques are concerned, Hence, any validation of the AEC procedures would have relevance to the present operation.

When the NSF took over this fellowship program it immediately set up a research function designed to improve the selection techniques. The National Academy of Sciences-National Research Council was called on to undertake this research, as it was also engaged in the process of evaluating the applicants for the NSF fellowships. Cal Taylor was the first director of this research operation; I succeeded him in 1954 when he returned to Utah.

The 1949 AEC candidates were the earliest group upon whom selection procedures closely resembling the present ones were employed. They were therefore the first ones upon whom on-the-job criterion measures might be available. The decision was made to follow up this early 1949 group to try to establish a criterion of scientific competence for the members of this group -- some criterion measures that would "sort out the men from the boys," so to speak. Our research efforts in this, as in other selection techniques research, were advised by a committee chaired by W. J. Brogden of Wisconsin, and which included John Stalnaker, now of the National Merit Scholarship Corporation; Robert Thorndike of Columbia; David McClelland, then of Wesleyan and now at Harvard, who participated in this conference two years ago; Dael Wolfle of the AAAS; and John Tukey, a mathematical statistician of Princeton. This committee recommended, as a practical first measure for criterion development, that the first follow-up might be done by means of the mailed questionnaire. (See Figure 1).

By dint of three follow-up letters after the original mail-out (the third follow-up letter carried fifty cents in bright-colored postage), we obtained a 90% response. About 5% of the people could not be located; another 5% just would not "talk." But apparently this is not a sufficiently large number of absentees from our original group to be of any particular concern. The non-responders are little different from the responders on the predictor measures, and we obtained a good spread on our criterion measures. This gave us a group of 504 men -- 347 in the physical sciences and 157 in the biological sciences.

There were 42 women who responded to the questionnaire. We simply eliminated them, not because of a lack of interest in scientific creativity among women, but for the very simple statistical reason that they were scattered over several fields and were insufficient in numbers in any one field for statistical analysis. It was clearly not valid to include them with the men in our analysis, because their criterion scores were far below those for the men. Thus, to include the women would be simply to break the analysis down into masculine-feminine differences rather than high-low competence differences. Obviously, we didn't want this kind of bias introduced.

Although we decided early that it would be necessary to depend upon the judgment of experts in each field to evaluate the questionnaires, it was also decided that we should attempt an objective analysis. By correlating the judgmental ratings with a number of objective reference variables, we could define more or less precisely what the judges were using as bases for their decisions. If these variables should prove to predict the judgments accurately, they would be a more economical substitute criterion for the judgments themselves. The variables extracted from the questionnaires included: (1) the number of publications, with partial credit for joint authorship, (2) income from technical and scientific work, (3) number and level of persons supervised, (4) major category of on-the-job activity, and (5) employer category. We also determined the year of attainment of the Ph. D., if any.

Figure 1. Condensed Version of Questionnaire Form

Bureau of Budget No. 99-5508
Approval Expires June 30, 1956

NATIONAL ACADEMY OF SCIENCES–NATIONAL RESEARCH COUNCIL

Office of Scientific Personnel Questionnaire for Former Fellowship Candidates

Name and Address

If address given is not
correct please make
necessary corrections

1. Education

Please list below your educational experience from 1949 to the present

Institution	Dates	Field	Degrees

2. Your Present Job

Title Date of Entry on Job

Employer's name and address

Nature of the work: Just what do you do?	If Federal employee, GS grade (or equiv.)

Supervisory responsibilities, if any. Briefly note nature of supervision, number and categories of persons supervised

Approximate percentage of your time devoted to each activity:

Research %	Teaching %	Administration %	Other Duties (Explain) %

What is your monthly income from scientific and technical activities? Check appropriate category to indicate approximate range:

$100+	$200+	$300+	$400+	$500+	$600+	$700+	$800+	$900+	$1000+

If you are not now employed on a regular academic job, please indicate an academic position giving rank, salary, and name of institution which you consider equivalent to your present job

Rank Salary Institution

Names and addresses of two to four persons best acquainted with your work

Figure 1 (continued)

3. Other Occupational and Military Experience

Include consultantships. List last previous job first; go back as far as 1949.

Job Title

Employer

Nature of the work: Just what did you do?

Dates From

To

Monthly salary. Check appropriate category.									
$100+	$200+	$300+	$400+	$500+	$600+	$700+	$800+	$900+	$1000+

(Three replications of above form omitted)

4. Patents

Please give separately (a) a list of patents granted, including titles and serial numbers (b) the number of patents applied for but not yet granted. (If additional space is required, use page 4 or additional sheets)

(Seven lines omitted)

5. Publications

Please list separately (a) published papers, giving titles and references (b) papers prepared for publication but not yet in print, giving titles and references where known and (c) number and approximate length of other papers, including classified or private reports. (Use page 4 or additional sheets if necessary)

(Half page omitted)

6. Scientific and Technical Societies

In what scientific or professional societies do you now hold membership, and what grade of membership do you hold?

(Three lines omitted)

What offices, if any, have you held in scientific or professional societies? Please list them, with dates.

(Four lines omitted)

7. Best Scientific or Technical Accomplishments

Please list below the two achievements which you consider your best since 1949:

(Four lines omitted)

8. Nominations of Outstanding Young Scientists

Please list below the names and addresses of up to four persons who have graduated since World War II and whom you feel are the outstanding younger scientists in your particular field.

(Three lines omitted)

Additional Comments

In the space below add any further information which you feel will be useful in giving a complete picture of your educational and job experience since 1949. This space may also be used to complete any previous items.

(Half page omitted)

The judges who rendered the subjective criterion ratings were, for the most part, members of the selection panels currently employed in the NSF fellowship program. Three or more independent judgments were sought for each questionnaire. Ratings were corrected for hard-easy rater bias, and then for field differences. Average ratings varied from field to field in a way which could not be accounted for in terms of differential achievements of people in the several fields, and as no inter-field ratings were available as calibrators, we simply equated all fields, e.g., to allow combinations within the physical science group.

The bio- and physical-science groups were kept separate in the analyses, as they had originally been evaluated by separate panels, and because the social forces operative in the two fields are distinctly different. There were marked differences, too, in the percentage of candidates awarded fellowships in the two fields, and in average ability in the two groups.

An important point to bear in mind is that we followed up both the people who were awarded fellowships and those that were not. And in the evaluation of these questionnaires by our panels, we combined the awardees and non-awardees. We were pretty sure that if the panelists knew which were awarded fellowships and which were not, this knowledge would introduce a bias we did not want.

The tables presented here show the intercorrelations of the various objective criterion elements with each other and with the subjective ratings, for the bio-science and physical science groups. The physical science fields included chemists, physicists, engineers, mathematicians, and geologists. In the bio-science fields there were no breakdowns. The overall criterion ratings were rendered by the panelists on a 10-step scale, using the whole questionnaire as a basis of judgment. We simply asked the panelists to make an over-all judgment. To determine what went into their judgment, we might have asked them, "What is most important to you?" We thought it was more realistic, however, in determining what actually was important, to use the correlation of this judgment with several other reference variables and objective criterion elements derived from the questionnaires themselves. It is these intercorrelations which you see in Tables 1 and 2.

In both of these tables you will notice that by far the heaviest weight is given to "publications." Our publications measure was a simple count of papers, without any attempt to evaluate their quality. We gave partial credit for multiple authorships. This variable is established by a purely clerical routine. The "adjusted income" is income adjusted for employer category. We found that the government paid $100 per month more than colleges and universities; industry paid $100 per month more than government -- for the same quality of people, as judged by the original selection instruments. I suspect that these employer differentials will increase with age of the scientists. These were mostly young people, some of whom had just obtained their Ph. D.'s. I should point out that this income adjustment was only for these three employer categories that I have mentioned. There was a forth "miscellaneous" category -- too miscellaneous to justify applying a correction across the board. On the average their incomes were far below the others', and they were lower on ability also (tests and confidential reports as of 1949).

Table 1

Inter-Correlations of Criterion Elements in Physical Sciences Group (N = 347)*

	Rating Criter.	Yr. of B. A.	Acad. Level	Yr. of Ph. D.	Acad. Prog.	Publi-cations	Adj. Income	Supervision Level	Supervision No.
Year of B. A.	.06								
Academic Level	.12	.34							
Year of Ph. D.	.40	.49	.33						
Acad. Progress	.36	-.39	-.04	.86					
Publications	.61	.01	.15	.35	.32				
Adjusted Income	.31	.16	.19	.28	.22	.21			
Supervision: Level	.19	-.02	.00	.19	.18	.04	.24		
Supervision: Number	.15	.05	.05	.15	.12	.02	.28	.83	
Mean	10.06	5.41	2.52	6.29	5.61	3.23	5.70	1.88	2.68
Standard Deviation	3.10	2.48	.52	2.32	2.68	2.58	1.47	1.85	3.08

Multiple R for predicting the Rating Criterion from Publications, Income, and Supervisory Level is .65.

Table 2

Inter-Correlations of Criterion Elements in Biological Sciences Group (N=157)*

	Rating Criter.	Yr. of B. A.	Acad. Level	Yr. of Ph. D.	Acad. Prog.	Publi-cations	Adj. Income	Supervision Level	Supervision No.
Year of B. A.	.09								
Academic Level	.24	.48							
Year of Ph. D.	.56	.12	.44						
Acad. Progress	.49	.00	.07	.90					
Publications	.76	.05	.20	.35	.31				
Adjusted Income	.34	.17	.24	.23	.17	.28			
Supervision: Level	.31	.05	.04	.14	.16	.20	.39		
Supervision: Number	.10	.06	.02	-.06	.00	.05	.37	.66	
Mean	10.55	4.66	2.03	5.04	5.27	3.78	4.56	2.05	2.67
Standard Deviation	3.78	3.07	.57	2.85	2.87	2.74	1.70	1.54	2.68

Multiple R for predicting the Rating Criterion from Publications, Income, and Supervisory Level is .78.

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[*] All data are in code scale form, and cannot be directly interpreted.

I have said that, on the average, these were young people. But the age span was great, and span of years since the B. A. was very large, too. Some candidates had attained the B. A. early in the century; a few were seniors at the time of application. The data in the tables are all in code scale form, so one cannot read the data directly. Also, the "year of Ph. D." scale is inverted, so that the earlier Ph. D.'s have the highest score on this scale. We did this to keep the correlations positive as much as possible, and early attainment of the doctorate appears to be a positive indicator. This will account in large part for the substantial correlation between the rating criterion and year of Ph. D. Those with early degrees have been out on the job longer, and have had more time to build up a criterion score. Some of these obtained their doctorates in 1949; some were still in school when they returned their questionnaires; all were fellowship candidates in 1949. The "academic level" variable sorts the men out according to whether they were just entering graduate school, were in their terminal year, or were somewhere in between at the time of fellowship application. Academic progress is a variable derived from academic level and year of Ph. D., and reflects relative speed in completion of the doctoral requirements.

Q--Did you remove the name of the former candidate when the panel made its ratings?

S--No. It wasn't feasible, as the bibliography is in there too. There were a few of the panelists who knew a few of the ratees, but for the most part they did not know them. I don't believe that there were any panelists who were members of the original selection board back in 1949; if there were, they had had plenty of time to forget anything they might have known in the intervening eight years.

C--It appears from the tables that virtually all that was considered by the raters was publications. Yet your Multiple $\underline{R}$ is considerably below 1.00. Do you have any idea of what other variables there might have been that influenced the panelists' judgment? Could there be something in connection with publications themselves, that doesn't go into your score? How about quality of papers? I'm also dubious about this joint authorship formula -- conditions vary so much from one situation to another and between industry and universities. Some supervisors insist on any associate or employee of theirs using the name of the supervisor on the publication; others never do.

S--This last point is one of the problems we couldn't control. And, of course, it occurs in both universities and government. Here are the average figures (code scales -- not actual numbers of publications) for the various categories of employers: For physical sciences: colleges, 3.48; government, 4.20; business and industry, 2.66; non-profit organizations, 3.71. For bio-sciences the figures are: colleges, 4.28; government, 4.79; business, 2.67; non-profit institutions, 3.50.

C--I know of a number of industrial situations where you cannot get a publication cleared unless you put on it the names of almost everybody in the organization. This could result in a great discount when, in fact, the writer was just one person. Maybe that's one of the reasons why the mean score for industry is so much lower. Of course, it might be that way in some government agencies, too.

C--Some of the most important discoveries in the field of physics made about 10 or 15 years ago contained as many as six or seven co-authors, and they took only a page in the publication but opened a whole field with their discovery. They wouldn't get much credit, on the basis you used for computing the publications score.

S--That's right. Quality might, of course, have been judged by the panelists and that could account for some of the unexplained variance. With respect to private reports or classified material, we simply had to take the respondent's word for it when he estimated the number and length of his reports. Length is another thing. Journal articles of whatever length were all considered alike, and a book would count for no more than a one-page note in the formula we used. However, there were practically no books. Almost all were journal articles.

Q--May I ask whether you're interested in the possibility of having a committee make ratings just on quality, and seeing whether it produces anything more than sheer number?

S--I think we'd get some unique variance -- it probably would account for some of the differences between those multiple R's in the .60's or .70's and 1.00. It would be difficult to do on titles alone, of course. We did get the panelists to give us estimates of the quality of the journals in which these papers were published. We made up an alphabetic list of all the journals mentioned, and got ratings of them. We haven't had time to analyze that, but I suspect that when we do, we'll be able to improve our criterion thereby. One point to remember in regard to number of publications, however, is that some of these people published nothing. They'd be zero's on any type of publications criterion.

Q--Didn't Shockley find a large correlation between number of publications and a rating criterion for scientists?

S--He did. One of the people working for him told me that when he was skeptical of this finding, Shockley told him, "O.K., go ahead and try it over again." He did, and the more he delved into the question, the more he found that confirmed Shockley's original results.

C--We found much the same thing in working with a highly creative group in contrast with a group consisting of persons who had not distinguished themselves in terms of creativity. There was no overlap whatever in the distributions, the former was so much higher than the latter. Of course, this was an unusually creative group, and probably one of the reasons they had come to the attention of so many people and got high ratings from their peers was through their publications.

C--That's a problem right now. The man working in guided missiles might be highly creative, but he won't publish much. Even if you count the number of reports as he gives them, he can't come to the attention of his peers through his publications.

S--That is a real limitation. I think that as more time passes, this same approach may develop more validity. The longer the time span, the more chance the creative people will have to publish and to become known.

C--This recent report by Kenneth Clark on America's psychologists may be pertinent here. Certainly number of publications was one of the principal criteria in selecting the highly visible group originally. But if you compare this highly visible group as a whole with the top 150, publications are of much less importance, if my memory serves me correctly.

C--I think you're right. But also, the median number of publications was zero for APA members. So I don't think we have as much restriction of range here as we might fear.

S--There were some here with zero scores, but not many. Perhaps this points to substantial self-selection of candidates, even of those who did not get fellowships.

C--How about the system of estimating importance that Kenneth Spence used -- not number of publications but the number of times a person's publications were referred to in other people's writings. Don Pelz used it too. I think this is probably a pretty good criterion -- but boy! think of counting them!

C--An analogy with the field of literature might be worth considering. We have a great many literary publications which are manifestly worthless, but there is some evidence of correlation between the number of publications and the very highest achievement. But aside from that, number of publications appears to be of no consequence whatever. Some of the most sensitive and powerful writers publish relatively little (if we can recognize sensitiveness and power and significance and so on). I don't know that any study has been attempted, but I venture to say that if we try to estimate a man's value in the field of literature by the total number of his publications, we would go far awry.

C--Perhaps the comparison is not good. You can function as a scientist without publishing anything, but you can't function as a literary figure without publishing. Of course, you can function as a discussant of literature, as a kind of appreciator of literature. There are some celebrated teachers, for example, who seem to have creativity and are expressive in this way.

Q--In your study, did you consider scientific competence as pertaining to personal output of some kind, or to output stimulated and encouraged by others? For example, the lower division teacher is really rated in terms of the development in his teaching. The graduate teacher is something else again.

S--This is a very real and important problem, but one which we have no means of attacking with the data at hand. The basic data we had were just the questionnaires, and we can't tell from that how good a teacher the person might have been.

C--The man in a supervisory capacity is a similar case. If he develops the people under him, he's a good supervisor, I would think. On the other hand, if he's the kind of supervisor who simply uses the people under him to enhance his own prominence, this would be no good.

Q--Have you done anything yet with the nominations of outstanding young scientists?

You could go through all your several hundred and count the times they were mentioned by their peers.

S--We were hoping to do that. The trouble is that one little word there ruined it. We asked for nominations "in your particular field." They were much too particular. They defined their fields so narrowly that there was practically no overlap.

Q--Has anyone ever played with the problem raised by President Olpin -- that of just trying to get people to list the kinds of problems on which they worked, and then maybe judge these for quality?

S--Item seven asks the respondent to list his best scientific or technical accomplishments. Some listed their theses. One of the women said, "raising three children." (Laughter.)

Q--Did they become scientists?

C--You might be creative but the problem you work on might not be very significant; when you get stuck with where you happen to work, are you creative or aren't you?

C--You can get out. Some people do.

C--We found in our interviewing that the response to a question like No. 7 depends on the situation. Some respond in terms of what has paid off most for the organization they're working for. That's different from what they might privately have been the most satisfied with. To get the latter, you may have to probe, or you'll get what has made a lot of money.

S--The question here is "what you consider your best." I wouldn't be surprised that the judges took this response into account. Some people stated very obvious and routine things as their best accomplishments. The judges probably thought, "If that's the best he can do, he gets a zero."

Q--Have you divided your awardees and non-awardees into two groups: universities on the one hand, and government and industry on the other? It is conceivable that these people are seeing two different worlds -- getting admitted to the academic world as different from these others. Is it not conceivable that the fellowship awardees tended to stay in the universities, never knowing that the party was over, and the others got out?

S--I don't have the figures at hand, but there were both awardees and non-awardees in both groups. There are plenty of awardees in business and industry, for example, and there are non-awardees who are working for colleges. There certainly isn't any clear dichotomy along the lines you suggest.

Q--Do the men on your panel come roughly equally from government, industry, and business?

S--They are mostly professors. I might point out a number of other interesting aspects to this criterion problem, only a few of which we have adequately explored. We have mentioned the income differential. There is also a matter of the relations between the criterion elements -- for example, between income and number of publications. Here the relationship is definitely not linear. It is curvilinear, and non-monotonic. That is, as income went up, publications went up also, to about the 75th percentile on income, and then dropped off.

Q--Is this a shift from active research to administration?

S--That could well be, although I haven't gone far enough yet to tell. I think it will be well worthwhile exploring to find the answers to such questions. We get a curvilinear relation of a similar shape when we correlate number of people supervised with highest level of person supervised. Those who supervise the largest number have nobody under them above mid-level -- i.e., about B. A. level. There are a number of relationships of this kind which we need to explore -- including, in this connection, employer category. It gets very complex, particularly because we are not dealing with linear relationships. The matter of inter-relationships between academic progress and on-job-criteria is another thing. We know that awardees finish sooner and get out on the job quicker than non-awardees, but do not yet know how much of this is due to the award and how much to the fact that they were more able in the first place.

C--There's one thing that concerns me a little bit. We're considering the identification of creative scientific talent here. Now publications per se is obviously not a talent, not a factor or a characteristic of an individual. It seems to me it's removed a little bit. In other words, we might ask "What are the factors which lead to publication?" Have you considered it from that point of view? Do these people who are scientifically competent write because they know that they have to write to get further support? In other words, there's a little bit of something that doesn't quite ring true when we are analyzing the competence. The publication is somewhat remote. I think motivation for publishing would be quite important, that is, whether a person is genuinely problem-oriented, and is publishing out of a need to present his results and get interaction with other people's results, etc., or whether it's largely another kind of motivation -- a shining of your own shoes.

C--One of the questions that might be asked is, "What is your employer's attitude toward publications?" Some companies just discourage it, while others encourage it. That would affect joint publication, too, if they have certain restrictions such as those mentioned earlier.

C--In our research in industrial settings we found no difference in reported number of publications between the more and the less creative -- the median was about 1.5 to 2.5. But when we asked a man whether he were subject to company restrictions, and sorted them on this response, we found that there was a significant difference between the groups in answer to the question, "How many papers do you think you could publish that you already have materials for?"

C--Another aspect is the willingness to accept the challenge of a problem. To attack a difficult problem can result in few publications, and yet some of the best men in the field of science will spend a lifetime trying to crack a tough problem. On the other hand, if an educational administrator puts emphasis on publications of research work, it's amazing how many lists of publications come from certain faculty members.

C--This is an area in which we have done very little research. There are other factors than those of kind of problem and attitude of administration. One is facilities. Let me give you a personal example. I worked in a situation in which I was criticized for going to another laboratory to borrow a calculator which we couldn't possibly afford. During that period I got out one publication. I am now in a situation where I don't have any choice about publications. That's my job, so in a period of much less than this, I have five times the productivity. Now this has got nothing to do with some of these other problems. It's a matter of the situation, and it's been very powerful in both cases. I think the study which we are reviewing here shows a typical psychological bias. We're trying to look inside the head for the most part because this is the easiest thing to do. Environmental studies are difficult and a first reaction to a proposal to study environmental conditions is "Well, you can't get a hold of it, you can't deal with it, so let's go back to our tests, " because these we can manipulate and we have a whole history of ways of manipulating which makes it much easier.

C--The IBM 701 is quite an environmental factor. (Laughter.)

C--This is quite true. I have a friend who's got so many projects on these things he doesn't know when they come out what he's got. He doesn't remember the study.

S--I'd certainly agree that situational factors make a lot of difference in the criterion. I'd also agree that this is a tremendously difficult thing to assess, and, of course, we haven't tackled it here. Perhaps you'd be interested in what preliminary data we have on the validity of our selection instruments, against the criterion we have here -- the subjective rating criterion, which we have seen is determined very largely by publications. Table 3 gives the correlations of this criterion with a series of 1949 predictor variables. You will notice that the cases are here sorted into physical and biological sciences, and sub-sorted into three groups by year of Ph. D.

We came out mostly with Irish coefficients (.01, .03, .07, O'Malley, O'Grady...). These coefficients are almost all disappointing. Some of them are negative. Most of them are essentially zeros. There are a few that may be significant, but they do not occur in a pattern that gives you a great deal of confidence. The highest one on the page is .27. This is for a variable derived from the Confidential Report. The confidential reports by the candidates' professors had a series of rating scales and also a free response portion which we were able to rate quantitatively. We were able to get a fairly reliable quantitative statement by looking it over and saying, "This person was trying to rate the candidate in group, say, 1, 2, ...5." These "descriptive report scores" as we called them, looked a little better, at least for some groups, than did the graphic rating itself. Another variable looked interesting, but didn't turn out well. I had suspected that there might be some cases where Confidential Reporters said they had no opportunity to observe in order to avoid saying something negative. So we counted up the number of times this "no opportunity" block was checked. But it has no validity either. Although some of these validity coefficients appear significant in some groups, right opposite you see zero coefficients in other groups, so I don't have much confidence in them.

Table 3

Validities of Predictors (1949) Against Rating Criterion (Achievement as of 1955 - 56) for Early, Middle, and Late Ph. D.'s

	Physical Sciences Year of Ph. D.			Biological Sciences Year of Ph. D.		
	1949 - 1951	1952 - 1954	1955 - 56 or none	1949 - 1951	1952 - 1954	1955 - 56 or none
Verbal Test	.09	.04	-.01	.06	.08	.35
Quantitative Test	.04	-.03	-.02	-.03	.19	.19
Advanced Ach. Test	-.05	.13	-.32	.06	-.04	.30
Undergraduate Science G.P.A.	-.03	.12	-.20	.14	.10	.13
Confidential Report: Graphic Rating	.17	.02	.18	.09	.23	.27
Conf. Report: Descriptive Report Score	.04	.11	.24	.05	.24	.22
Total Number Checks No Opportunity to Observe	.08	-.01	-.01	-.07	.11	.16
Number of Cases	216	91	39	65	54	38
Criterion Mean	5.16	4.48	3.44	5.71	5.46	3.21
Standard Deviation	1.47	1.46	1.57	1.52	1.40	1.85

Q--Could you tell us whether the people who were awarded fellowships had higher mean criterion scores than the people who weren't, and how much?

S--Yes, they did, but the differences were very small, and not significant. There was a great deal of overlapping.

Q--Does this suggest that if the fellowship board had reversed its listing, they wouldn't have done much worse?

S--As far as this criterion is concerned, they might as well have tossed dice.

However, I shouldn't say that I think tossing dice is the way to select fellows. I think that the trouble is with the criterion measure, in large part. In addition to the limitations of the publications element, which we have discussed, there are other difficulties with the questionnaire approach. In any questionnaire, we get only what the respondent is able and willing to report, for those who are willing to report. There wasn't a sufficient time lapse to be sure of opportunity for some people to develop criterion scores. And although in this table we have controlled year of Ph. D. to some extent, that doesn't answer all the questions. When we do that, we also control ability to some extent. There was a further limitation in the evaluations of the questionnaires. The scientists who made the evaluations spent, on the average, not over five minutes per questionnaire in making their judgments. I think that all of these things indicate that we need to go further with our criterion. Among the things which I would like to do would be to interview the people on the job, their co-workers, their bosses, etc. If we did this, I think we would get a lot more variance, and I think it might perhaps be more valid variance.

Q--Don't you have a very select group in the first place, so that it may be very hard to pick out the better from the not so good, any way you try it?

S--We took both awardees and non-awardees together in this analysis, and there were some of the latter who were not very highly selected. Anybody can apply, you know, and taking this entire group as a whole, I think we had enough predictor variance. The grade point averages, for example, varied from C on up. At the present time in the NSF Fellowship program we get mostly people with A's and B's.

C--I get somewhat concerned about this. We've put a lot of effort into the selection of people. National Merit Scholarship Corporation selects 1,000 out of 160,000. National Science Foundation comes along and does much the same thing. Then you come along with this kind of material suggesting that maybe it doesn't make much difference one way or the other -- that you could have taken the same cases and pulled them from the bottom end rather than the top end. Cal Taylor gives us much the same kind of information. I think that Don Taylor has somewhat the same kind of data. Although I think that there are some questions we might raise about the criterion, I still think they are not so bad but that we should find some relationship if our earlier work were sound. Somewhere in here I think we have to face this problem of where we are in really solving this selection problem. That is, we're making tremendous social judgments about people in terms of awards, in terms of who may and who may not go on, and we are now wondering whether these judgments have any consequences outside the narrow walls of our universities. We are forced to make these judgments, and the question is whether we could really have reversed the whole process and done just about as well.

S--I suspect that even with these present data and with the ratings we have, by re-sorting the groups in a little different way and by taking some other measures into account, we might come up with some validity yet. We might also come up with some other valid predictor measures that were not used.

C--I think the kind of finding you have here has been repeated in many fields. It's certainly true that when it comes to criteria for medical performance, for example, the basic reason for low validity coefficients is that after a certain fairly low cutting point in intellectual aptitudes, motivational factors account for almost all the real variance in criterion performances. Of course, the only way you can nail that down is to allow the motivational variables a chance to show themselves.

S--We have little of such variables here, of course One possible way of getting at some of it might be age at attainment of the B. A. degree. We haven't gotten at that yet, but it is a variable that involves a combination of motivation and ability. I suspect that it will be a useful predictor at least of academic success, and I hope it may be a better measure than some of the present variables in predicting on-the-job criteria.

C--Some of us are on the receiving end of this and have to make these choices. They affect people -- how much money they get and whether they work for you or whether they don't. I'm a little concerned with this seeking to measure what we might consider secondary elements, like number of patents or papers. I wonder whether in setting up your criterion groups you could go to the actual products of the man. When we select people in our agency, we ask them to submit copies of their papers, and then scientists who are working in that field evaluate those papers. We have tried to get a scale of evaluation of the products and we've come to use this also to decide how much pay to give our scientists. We've gotten a structure wherein they evaluate the product in terms of the wideness of the problem solved. Often a man will solve one problem and the solution takes care not only of the problem he's working on, but a whole variety of problems. We have come to the conclusion that the broader the area, the more fundamental and creative the efforts that have been put out. So we use that in deciding the level of the products of our scientists. We use this evaluation in rewarding them in many other ways than money. We have found that this system stands up in terms of what the scientists themselves think. I might mention an attitude survey of most research and engineering people in government and also in six private industries. One of the questions asked was: How well do you think they have placed you in the hierarchy, and how well have they classified you? Our organization came off very well. I think we are the only ones that are doing the type of evaluation I mentioned, and we were about the highest in terms of the satisfaction of the individual scientist in the way he's been placed in the structure, and how his work was evaluated. If we could get a little closer to the actual product and stay away from what we hope are highly correlated with the actual product, we might have a little more success in getting predictor measures that correlate with our criterion.

C--Do you have some sort of copies of materials as your guide lines for these product judgments?

C--Well, this thing is a little bit hard to put down. What we do is to take a research product and evaluate how fundamental that research product is, and how broad an area it will apply to. We ask how many solutions it will provide, whether it will open up a new area of research, and whether it affects many different processes. We have a sort of a scale of what we call "class descriptions" in which we describe the type of a problem and the type of a solution that will fall at a given level. We depend a great deal on the scientists to help us in their particular fields. We've found that we need the people who are working in a field to evaluate solutions in that field. For example, we want the people who are working in theoretical aerodynamics to evaluate a contribution to theoretical aerodynamics.

Q--Are you getting this kind of evaluation continually on your current employees?

C--Yes, we have personnel advisory groups of scientists who continually are evaluating the people as they come up for promotion, or change in assignment, or any other evaluation such as for special awards or other attributes of recognition.

Q--Have you tried to evaluate predictors against these kinds of criteria?

C--No, that's what we're anxious to do. We think we've pretty well isolated the good persons, and have moved the good ones forward -- the ones that are most creative. One thing we've done: we've separated two channels, so that the creative man without any line supervision or organizational position can go clear to the top. People who are merely working on gadgets don't go to the top in terms of our evaluation. We think basic research has been much more fruitful. We have large numbers of individual creators who go to the very top of our organization in terms of pay and other recognitions. We use them as spark plugs. They're independent; they have no organizational spaces, but they spread their ideas through people around them. What we would like to do now that we have put them on a continuum of creativity is to determine what things we can measure in these people that will give us prior indications.

EARLY DIFFERENTIATION OF INTERESTS

Anne Roe
New York City

S--I am going to give you briefly some material which is suggestive of a possible approach to our topic, although it may appear to be a little bit off from an exact focus. Even though this approach has been neglected, I think it is important.

I became involved in interests quite unintentionally when I was doing my initial work with artists and with scientists. I had taken the various interests as "givens" and had not been concerned about where they arose. Furthermore, I was not using any technical measures of interest, which I now think was a mistake. However, when writing my book on the psychology of occupations in which I tried to survey the field quite fully, I was very much impressed by the fact that interests seemed to be more important than aptitudes in terms of final occupational choice and satisfaction. The other thing that impressed me much more strongly than before, was the importance of the general socio-economic background as it affected one's selection of occupation and probably as it affected one's interests. Following this, I have been brooding for some time about how interests develop, e.g., why some people are interested in science and some people are not interested in science. It is not just aptitude, because correlations between aptitudes and interests are only in the .30's, which is not enough to account for the actual situation.

As a result of these cogitations, I have developed a theory, part of which I am going to present to you this afternoon. I am not going to go through all the series of hypotheses, but will just present one part of it to you. The theory derives from a great many different studies -- biological studies, my own studies of scientists and of artists, analytical studies, case histories, studies of child rearing, factorial analyses of interests and of aptitudes, and so on. I have tried to put them together to make some sense out of the problem: "Why do people have different kinds of interests."

One of the first cues I got was from some of the early differences in biographies and the life histories of the artists and the scientists whom I studied individually. Subject to the usual qualifications of other things being equal (which of course, they never are), I have what I think may be some leads as to how people develop certain interests rather than others. This approach is relevant to the general problem of creativity in the sense that some of the things which cause differences in interests will also cause differences in creativity.

It is my firm conviction that our problem is not to develop creativity but to keep from inhibiting creativity. In other words, I think that the creative approach to life is built into the human species -- as part of our normal functioning -- and that our problem is to let it go rather than to get it started. Therefore, whatever affects our interests, will, of course, affect the areas in which we are able to function creatively and may also be among the factors which do or do not permit creative functioning.

Q--When you say that creativity is built into organisms, do you mean to equal degrees?

S--No more than I would say that we are all equally tall, but I think that this is a basic mechanism which functions more efficiently in some people than in others.

Q--Everybody has some?

S--That's right. I would go a little farther than that, but I would rather not get off on that point at this moment. We must distinguish, I think, between the creative process -- the handling an incident or reacting to a situation creatively -- and the creative product. The results of our behavior in some situations have social relevance or emotional relevance to other people. But behaviors arise out of no more creative a process than something that has only personal relevance to us. So we must try to distinguish between the process and the product. They are two different things. Do not forget that the appreciation of the product varies a great deal from one time to another in the same culture, from one culture to another, and so on. Many of these factors affect our assessment of what has been done. But the process itself is something else again -- not the same as the product.

Now let us turn to the theory. Basically my feeling about the origin and development of interests is that they arise out of the child's earliest experiences in the family. They are determined primarily by the areas in which his attention is given free flow in the family structure and the way in which he is handled in particular situations.

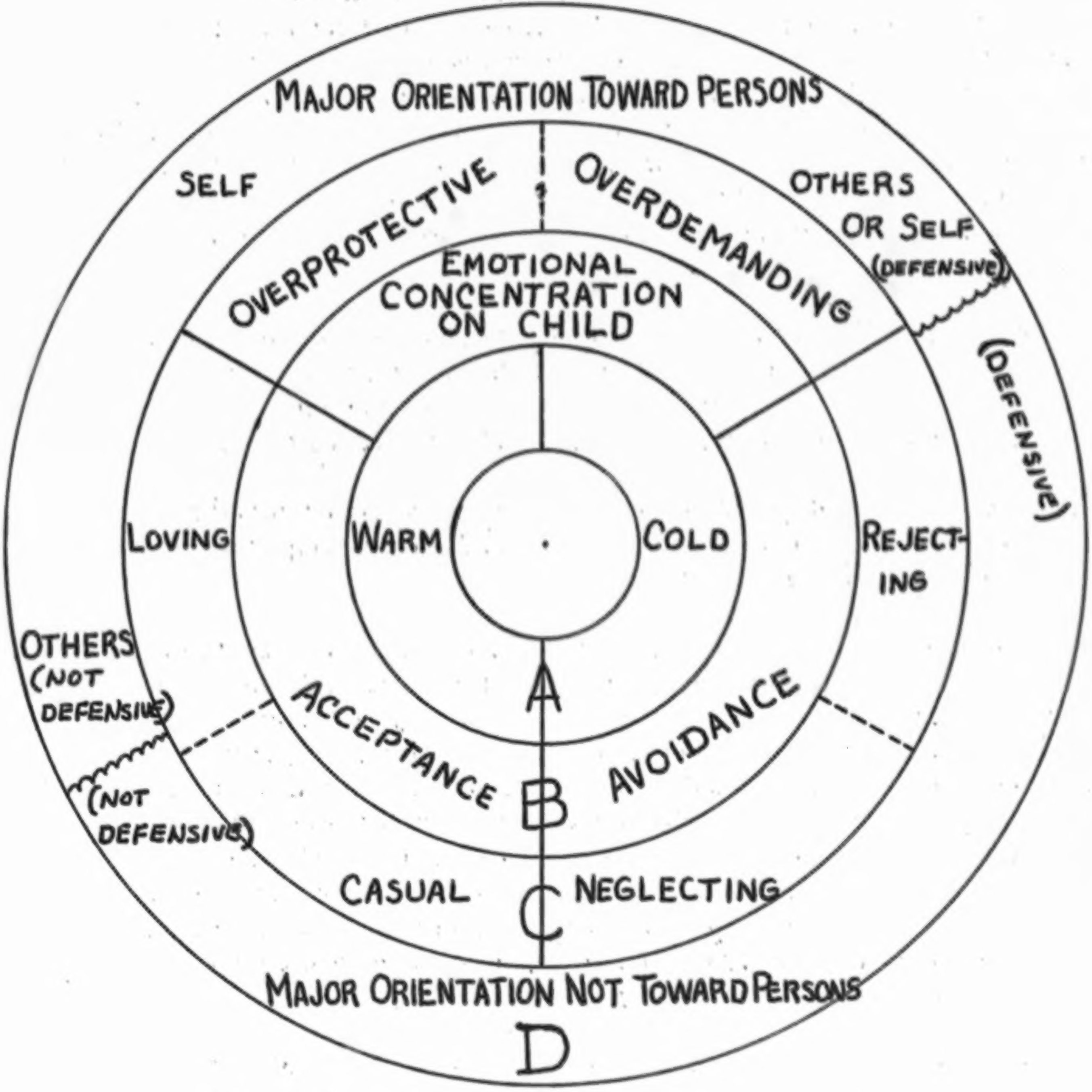
There are a number of qualifications as to why his attention gets directed one way or another, but I am going to skip those, too, and just try to give a diagram of what I think may be the general pattern.

First, we must consider that children are handled differently by different parents. There are different degrees of emotional warmth. There are different degrees of demands put upon children. Sears' new book on child rearing, for example, points out the large range of different ways of handling children. Purely for purposes of this analysis, I have split up what I consider to be a continua of methods of handling children into arbitrary subdivisions. I use a circular diagram for this presentation because I think one method runs into another. The methods keep going around and around. For example, homes have a sort of basic attitude towards children which is warm or cold. That is, the emotional climate in the home varies through a whole range from coldness, getting a little warmer, getting warm, and then getting colder and colder again. This is a continuum. (See Circle A, Figure 1.)

As an additional refinement of this general problem, I think of three major nexus of attitudes towards handling children shown in Circle B of Figure 1. One of them I call emotional concentration on the child. The child is the center of the home -- is the major object of concern. In any balance of relationships, the child is where the focus comes.

Emotional concentration on the child can be expressed in various ways. It can be expressed, as it frequently is, as "overprotection of the child." It can also be expressed in another way as "overdemanding." In its extreme form as we move around the continuum, we find parents who are overdemanding of their children to the extent that they expect of them what one should not expect of children, and you can see that psychologically this attitude becomes more and more closely related to rejection of the child as a child. (See Circle C, Figure 1.)

Figure 1


MAJOR ORIENTATION TOWARD PERSONS
SELF
OVERPROTECTIVE
OVERDEMANDING
OTHERS OR SELF (DEFENSIVE)
(DEFENSIVE)
EMOTIONAL CONCENTRATION ON CHILD
LOVING
WARM
COLD
REJECTING
OTHERS (NOT DEFENSIVE)
(NOT DEFENSIVE)
A
ACCEPTANCE
AVOIDANCE
B
CASUAL
NEGLECTING
C
MAJOR ORIENTATION NOT TOWARD PERSONS
D

A second major category in Circle B is "avoidance." Avoidance subdivides into rejection and neglect, which run into one another. (See Circle C.)

The third major category in Circle B is "acceptance." In the Circle C breakdown of this category of acceptance, next to the subdivision of neglect of children, we have sort of a casual acceptance. The children are there and they get their due, and no one pays too much attention, although they are taken care of. The next category under acceptance is what I call, "loving acceptance," and which then shades into overloving in the sense of overprotection. This particular breakdown fits very well the material from the Fels studies and the California studies of children and other studies. It doesn't derive specifically from any one of them, but it fits them quite well.

Q--Does it fit with Ralph's analysis of the Fels data?

S--I don't know that one but...

C--He factor analyzed the Fels results.

S--Yes, it fits that partly and also there is factor analysis of the California data which it fits pretty well, too, although the edges are fuzzy, of course.

Now what has this got to do with what interests one develops? My hypothesis is shown in Circle D in the figure. The previous breakdowns have been arbitrary, so I put them in Figure 1 as solid lines. Now I am guessing, so jagged lines are used to represent the breakdowns. I think that the first distinction in basic attitudes which later develops into interests is whether or not your basic orientation is toward persons, while the others have a basic orientation "not toward persons." I do not say away from persons, because I do not think it is necessarily defensive particularly on the left side of Circle D, but the crucial cue used is the thing which catches their attention effortlessly. To what do you attend without effort? To what element of a new situation do you attend first? The primary break is, I believe, either the persons in the situation or the other elements in the situation. Again I do not use the term, basic orientation toward objects, because it is not necessarily objects, and anyhow, if you use objects in the psychoanalytic sense, you generally wind up with persons anyway, but not always, which is just confusing.

In the upper part of Circle D, the basic orientation toward persons can be either toward the self as a person or toward other persons. It can be an attitude toward persons which is outgoing and free because these interests, these relationships, have been the richest and most interesting for you, or it can be a cautious orientation toward persons, as found on the right side of the circle where people must be watched. The basic orientation is still toward persons, but it can be a defensive one or it can be a non-defensive one. What does this mean in terms of the interests that develop? I think, for example, that we have a group of persons in this overemotional concentration -- the overprotecting and the overdemanding-- whose early experience with adults around them is of people extremely close to them who are always emphasizing the personal reaction. Here you get the mother who sees to it that a child has everything, but doesn't get a chance to express himself very much because he might fall or hurt himself, or something might happen to him. So he is somewhat restricted, but the concentration is on the child. Here you get the sort of upbringing that you have with parents who keep the child to a very high standard of performance. When it gets to a standard of performance which is totally unrealistic for a child, you get around in the rejected area. Or in this area it can be unrealistic in the sense of keeping the child entirely concentrated upon types of things in which children are not primarily interested.

Following this then you would find the development of someone who has to be cautious about other people because they expect too much of him.

Out of this group you get people suited to occupations in which the most important element is the relationship of one individual to another. For example, at the upper level of occupations will be personal therapists, vocational guidance people, welfare workers -- of one sort or another -- social workers, and so on. At the lower level of occupations there will be barbers, beauticians, etc., in which there is a direct personal relationship. You will also get what I call the arts and entertainment group of occupations, where I think a major element is a form of narcissism which derives out of this framework. I do not separate music and painting and other arts, because I think the essential element is the same in them, and I would include big league baseball players, for example, in the same group. Here the narcissism refers to a different sort of body structure than it would in terms of the artist.

In groups with basic orientation not toward persons, there can be an orientation toward things or objects in the environment which may be animate or inanimate, or perhaps toward the ideas, although you will get some orientation of a very limited sort toward ideas in the other previous group. Primarily many scientists -- except some social scientists -- will come out of this latter group. Obviously, I am generalizing very broadly, and there may be some exceptions.

In the neglected group and in the casual acceptance group, you will get persons whose basic orientation is not toward persons -- in a non-defensive way. I do not agree with the analysts that if you are not basically oriented toward persons it is because of defense against them. I know too many scientists who do not show this, but in whom the primary interest -- the thing they think about most easily, the thing they attend to most easily -- is a thing or object or animal, not persons. These persons will develop into a technological group, i.e., a biological sciences group, a physical sciences group, etc.

I suspect that interests develop out of aptitudes in some persons from the acceptance groups because there are no serious pressures put upon them either way. They manifest an aptitude and they get a chance to try it out -- either because nobody is paying too close attention to them or because it is part of the philosophy of their parents to give them a chance to develop this aptitude without trying to be too guiding about it. I think that in these persons, we might get the purest expression of aptitudes. I think that one reason why aptitudes and interests do not correlate more closely than they do is that aptitudes have primarily a genetic basis. Although they have to have a chance in the life of the child to come to fruition under expression, interests, for the most part, have an experiential basis and they may or may not coincide with aptitudes.

One can explain sex differences of interests on this basis, too. I think that the expectations of behavior for girls and boys are very different. Parents react very differently to girls than they do to boys. You will also find differences in the attitudes of parents to the first and second and third and fourth children. A whole structure which will bring one child up with this sort of an emotional concentration may get around to another part of the circle here for the second child. This transition is quite common because very young parents particularly in the upper middle class group -- are extremely anxious with their first children. I think if anybody made a study of fears you have for your first child, and the fears you have for your second child, you would find the fears decreased not only in number, but also in irrationality of content. I believe that you get more of this emotional concentration with first children, and as a result you may get a stronger motivational effect.

Now the problem of creativity comes in. It is much more difficult to get free flowing creativity from the groups at the top of the diagram. You will get it on a defensive basis, and this is the way you often get it in arts. This means you have to fight other things aside in order to concentrate on this one thing. I don't think that that necessarily happens in some of these groups at the bottom of the diagram. In fact, I was rather surprised to find in some of my studies of physical scientists particularly, a freedom and ease of working creatively, much more than I found in the social scientists, rather more than I found in the biological scientists, and I think considerably more than I found in the artists I studied. The artists usually got themselves into a terrific stew just before they were about to create something. To some extent this stirred-up condition happens in scientists, but I think it occurs to a lesser extent and has a different quality.

Next, we come to the problem of developing more scientific personnel. You are not going to get somebody who will work effectively in science if he is not interested in science. You have to start with this fact. A caution which I forgot to give you is that I am not suggesting that a third of our parents are emotionally concentrated and a third of them are avoiding and a third of them are accepting. There is no quantitative relationship here. However, with respect to the particular problem of who becomes a scientist, I would suggest that child-rearing patterns vary with different socio-economic levels. I suspect that there are a great many potential scientists in lower socio-economic levels where casual acceptance of a child by parents is much easier than it is for those who follow the women's magazines and read very carefully every month what they should do. However, I believe that most of these potential scientists are being lost because their lower socio-economic status does not give them a chance to feel that they could become scientists if they wanted to.

Q--Do you make a distinction between the attitude of the father and the mother in this matter?

S--No, I have combined them, but I think the difference may be very important. It is a factor which I could not take into consideration in this already highly schematized diagram. Actually, in most households, the attitude of the mother is more important; she is the one who is with the children most of the time.

Q--How does this fit with the finding that such a large proportion of our scientists are only children or first children? They should be in this top segment of your circle.

S--There is another factor present. Only children are not necessarily always overprotected, but I think the main factor in them is strength of motivation, which is not represented in the diagram. Pressure to accomplish may be associated with overdemandingness or it may be associated with a sort of loving acceptance. (Yes, John, you want to do this. Allright, I will give you the chance to do it. But still do it!) But this is within the limitations of what the child wants to do, not what the parent wants the child to do. There is a definite distinction.

C--Somebody reported a study two years ago in which they said if the conditions were such that the relationship between the father and the child would cause the hair to rise on the back of the son's neck, that the son is more apt to be a creative scientist. (Laughter.)

S--He will probably become a psychologist. (Laughter.) Actually, in attitudes toward their father there was a real distinction in my very small groups (let's face it, my groups are small) between the physical and biological scientists on the one hand and the social scientists on the other. Most of the physical scientists had a very real respect for their father but not a close affection for them, which, however, was not true of their attitudes toward their mother. Most of my social scientists, but by no means all of them, were still mad at their fathers or their mothers or both. They were still fighting a battle from which they had not become free. The more clinically oriented they were, the more this generalization was true. A good way to handle your battles, you know, is to extrapolate them. It is just nonsense to think that the scientist is truly objective. He works on things that matter to him.

The next point which was mentioned previously is that our problem is not to develop creativity but to keep from inhibiting it, and I think that our schools are not well designed to promote creativity. We put the answers in the back of the book and you had better know that answer! I think that multiple choice examinations are a terrible thing in this respect, too.

C--I am somewhat concerned about your assumption of the genetic quality of aptitudes. It seems to me that there is considerable evidence that the so-called general intelligence factor seems to have swallowed up most of the variance of high-level aptitude tests in the early years (I have seen some of Thurstone's data and the like), and that as we follow groups over a period of time, we find less and less correlation among the so-called primary mental abilities. What I am trying to suggest is that interest and aptitude are interwoven. I am sure there is a basic neurological structure of the individual and feel that it may permit him to move one way or another.

S--They are interwoven. For example, look at the results for girls in mechanical aptitudes. They are way down on the scale all the time. How much of this result is because of a sex-linked character genetically, nobody knows. Obviously, a considerable part of this result is because girls are not supposed to take clocks apart and boys are, so the girls get discouraged from it because they are not following role models. There are many other things involved in these situations. If you are not in a situation where you get a chance to find out that you have good spatial perception, for example, it does not worry you. But I think that overall there is a larger genetic factor in aptitudes than there is in interests, which may be one reason why high correlations are not found between the two.

C--I think the correlations are much higher than typically reported and I think it has to do with the methods of analysis used.

Q--What would you say about the appearance of multiple interests which vie with one another and perhaps to some extent are indulged, as in science, music, one or another of the arts, and perhaps in philosophy?

S--I do not know. What is there to say? Some people have a number of aptitudes on a high level. When given a chance, these aptitudes may flower. If these aptitudes have not been slapped down here or there or someplace else, or if the person does not need, in working out his difficulties, to follow one particular line, or if he does not have to take refuge from anxiety into one alley which he can control narrowly, then these aptitudes may get a chance for broad expression.

C--Perhaps the choice might be a matter of determination through the kind of pressures that you have suggested -- if the choice is actually made, which is altogether likely in our society where specialization is pretty much demanded for advancement.

S--You cannot make a conscious choice until you know what choices are open. The choice you make is limited by the choices of which you are aware, not just academic choices but choices possible for you as an individual. This is another one of the factors.

Q--My question relates to the genetic course of development of an individual. As we look at your scheme, it seems static, i.e., the child grows up in one or the other of these. But is it not entirely possible that the segment of the circle in which he is living changes as he grows up? The family attitudes change?

S--Family attitudes can change and the person also gets outside of the family -- in school where he gets a broader exposure. This diagram is intended to be an expanding sort of thing, you see.

Q--What is there to prevent a person from running around in circles?

S--Once you get habits of attention, things get fixed pretty fast. And if the things to which you react (because you are always reacting selectively, of course) bring the necessary satisfaction, reinforcement will result.

Q--Suppose you start out in one of these lower, less neutral segments like the casual acceptance state.

S--I doubt that you would ever become deeply involved in persons as a major factor, but I certainly will not say that you will not.

Q--No, but supposing that you start there and the family situation changes somehow. The mother or father for some reason becomes much more emotionally concerned about the children and so impose on them a different set of attitudes.

S--There are two answers to your question. In the first place, I know no case materials so I cannot tell you what actually happened. I would guess that if the changes were very sudden and very severe, the child would react with suspicion, in a sense not knowing what was meant by the new situation. He would be uneasy in it and might react as such. You are thinking, for example, if a non-loving father dies and the mother marries a man who is loving toward the child. But in the meantime, if the child is five or six, he won't have been getting these satisfactions in terms of personal interactions. He will be getting them in terms of investigating the world around him and this will probably continue, but he may be able to incorporate the other also. This is highly schematized.

Q--I am still working on this problem of getting the scientists who are the first and only children over from the one segment to where the....

S--But not all first children are in any one segment.

C--I assume you are saying it only applies to the generality of cases to which there are exceptions. But statistically one finds the concentration in a place which does not accord with the schema that you have here and yet this schema seems rational. So I am trying to move these people around to rationalize this discrepancy.

S--I think the only thing you can do is to examine individual case histories. I am thinking of one of my physicists who is an only child. Yet he belongs very distinctly in the casual acceptance area. One of my biologists was not an only child, but his mother died when he was three and from that time on, he belonged there, too.

Q--I was interested in implementing this in terms of a biographical information blank. I wondered if you thought that biographical items in the past had been getting at these things, or if not, what kind of items would you write to strike at them?

S--Well, you can't ask a child very effectively. You can't ask an adult and get away with it frequently, "Did your parents neglect you?" The most useful question (for a blank it is difficult to use, but in interviews you can use it) is: "How do you plan to bring up your children differently from the way you were brought up?" This question will get you a lot of material from persons who have said, "Oh, I got along fine with my parents." So you say that this is lovely, but how would you plan to do things differently. You know, times have changed.

Q--Are there many other questions which you could ask?

S--That is the most useful one from my experience. Another way in which I got at parental relations most effectively was to follow through on some of the information from the TAT, particularly card one and card four, and say "Well, it's funny, but I don't get the feeling which you feel about this card." But frequently you can get at it directly. The most useful feature of the projective techniques is as a check on other data. Of course, the TAT can be wrong, or you can be wrong in your interpretations. I rely much more heavily upon what the subject says, how he says it, and what the sequence of the report is, and then ask him a few questions such as the one suggested here. Another question was "If you could choose your parents -- if you could choose the sort of family situation under which you would be born, what would you choose?" "Whom would you rather be now, or as a child, if you weren't yourself?" "Which children did you envy and why?" These semi-direct questions are quite useful, but I don't quite see how you could put them on to a biographical blank which you were just going to check.

Q--I wanted to ask how the parents' interests might be reflected. Suppose you had parents who casually accepted their children, but were tremendously interested in people? Say that they were social workers or psychologists. All that was discussed around the dinner table was about people and the books in the house were about people and there weren't any tools in the house.

S--I would like to see that situation. I find it very difficult to conceive -- people who are very casual about their children and still are very involved in other people.

C--In other words, parents are going to show interests that conform to the very way they handle their children.

S--Of course, if the child is brought up in a family where there are no tools and so on -- they don't have them at home, but how about the boy next door?

C--We could turn around and say that the physical scientist who is in the overdemanding category gets you in the same dilemma. Maybe that's more reasonable.

S--In order to get away from the overdemanding, he goes around the corner and plays with the chemistry set and blows up the neighbor's house instead of his own.

Q--It brought up a question of how would you account for a situation which parents have learned from magazines or from doctors or wherever -- one set of attitudes which are inconsistent with their basic emotion, so that they may in some areas behave with casual acceptance, and in others with overprotection.

S--I don't think children are fooled by what parents read. I think they react to the parents' basic attitudes.

C--I would like to propose that maybe the significant finding for the only child and quite possibly the eldest child, might be due to their rather unique level of competition and experience. Certainly the only child and probably to a degree the eldest child, has a very real goal rivalry with parents. The combat region there is more highly concentrated between the child and the parents, so he is in the big league. The child with many siblings has most of his battlefields at a level where he is competing with peers and, therefore, he is content with whatever victory he can get in little league play. Therefore, by the intensity of the competition, the only child actually might be directed toward a struggle at a higher level than perhaps one of the five to six sibling family level. I would like to see these same factors in your circle applied to the parent. I see here you talk about the child and there is an implication that this is something super-imposed over the child. Now there is a tremendous interaction and I could translate some of these to the role of especially the young father, whom we are seeking in terms of creative leadership. Would the best family man be the one basically oriented toward persons and would the best scientist be basically oriented not toward his family or other persons. This other side of the drawing is very unique when translated over to parents.

S--I think that is a charming idea and I hope that somebody will do it both ways. I certainly don't mean to say, being a parent myself, that whatever happens to your children is all your fault. And certainly what happens to the parent is often or sometimes set in motion by the child. These are interacting variables. We start from the parent because usually the parent has a little more control over the situation than the child, but it sometimes turns out that it does not work that way.

C--You talked about using open-ended questions and saying that you have problems evaluating these. I wonder if you have considered exploring the keys of the Strong to see what you could get out of it in terms of etiology?

S--I went through about 20 keys of the Strong about three years ago and pulled out all of the significant items to see if I could construct clinical hypotheses in which these would fit. My original intention was to include these as part of the evidence of personality in different occupations. For the most part I did not because only about a half dozen came out elegantly in this sense. The banker key, the key for mathematicians, for example, gave beautiful material, but a number of the others did not, at least to me, and they were so uneven in this respect that I finally did not include them for the most part in my analysis of different occupations. It is a good thing to do and maybe if I tried it again, I might get farther with some of these which I did not find enlightening at the time. And also I did not go over many of them. It took me over a month on the 20 I examined, but it is a fruitful approach.

C--On the Strong we are finding very consistently that the artist key when used in the scientific fields is correlated with ratings of originality and the psychology key is correlated regularly with originality in the physical sciences. For example, the highest score for many of our highly original physicists who were candidates for the Ph.D., was on the psychology key.

C--On the biographical data blank that I used one question was, "Which subject do you least like?" This question approached significance, but did not quite reach it. The favorable answer was not to mention psychology among which you least like, or sociology, or some of the other social sciences. This was consistent with your findings and in the same direction.

THE DEFINITION AND MEASUREMENT OF INGENUITY

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S--This paper will describe the application of a new approach to the general topic of the identification of creative scientific talent. This approach has been found effective in working on other problems. The discussion will include a detailed outline of this approach and some applications to certain aspects of the problem of creativity.

The approach proposed for the identification of a particular variety of talent involves as the first step a careful study of that activity to find out what things are really critical in determining success or failure. This is based on the assumption that a good understanding of the activity and the factors making for success and a comprehensive list of the behaviors which produce success, as well as those which contribute to failure, will provide a very good start on the problem of identifying this type of behavior. Procedures have also been developed for constructing practical measuring devices from these detailed behavioral statements of the activity.

The first application of these procedures to problems in this area was in a series of studies started a number of years ago for the Office of Naval Research. The first study in that series was the formulation of the critical requirements for research personnel. This study was published in March 1949. It involved the interviewing of about 500 scientists in research laboratories and getting from them 3300 critical behaviors -- something they had observed someone do which helped get some solution to the particular problem on which their department in the laboratory was working, or something which somebody did which unfortunately interfered with making progress on this particular project. In this study the aim was not identifying good and poor scientists, or good and poor research people, it was entirely directed toward identifying effective and ineffective behaviors. Sometimes effective behavior was shown by a generally ineffective research worker, or sometimes the ineffective behavior was shown by a generally effective person. The aim was to focus on what research personnel did that was effective, not on effective research personnel. Of the 3300 behaviors reported, only 166 (just about 5%) had to do with "formulating problems and hypotheses" which relates to creativity. These included behaviors regarding the identifying and exploring of problems, defining problems, and setting up hypotheses.

It is suggested that in order to make a systematic study of creativity, a sample of about 3000 critical behaviors, all observed to have contributed directly in either a positive or a negative way to the creative processes be collected. In most cases these would be reported by the persons who had the creative idea. The reports would include the facts about the situation, just what happened, what the circumstances were and why this behavior contributed to the idea. These incidents would supply a relatively sound basis for the analysis of creative behavior.

Tuska, in his book Inventors and Inventions, has described about 42 classical case studies such as Edison's invention of the phonograph, Morse and the telegraph, and Bell's development of the telephone. These case studies are very valuable in improving understanding of the inventive process. However, supplementation involving more specific behaviors appears desirable. Thus it is necessary to collect large samples of critical incidents showing creative behavior. They should include some negative things of the type included in the sample of 166 previously mentioned. For example, one worker allowed a successful technique to be dropped without further application to new problems. Another overlooked a problem arising in his current work and needing further research. Still another failed to investigate unexpected results or difficulties encountered in work on a specific problem.

On the positive side, a researcher reformulated a theory to improve its explanation of the facts. Another applied a theory from another field to explain the observed phenomena. These are the sorts of summary behaviors formulated from five or ten or sometimes more critical behaviors.

The next step is to develop a measure of the particular job element, in this case, creativity. Since most readers are quite familiar with Guilford's approach to studying the structure of intellect, it seems desirable to indicate how this approach differs from the approach he used and also its similarities. One might say briefly that his approach is to study all kinds of specific activities and find out what their interrelations are and develop a classification system showing a factor analysis solution to the structure of intellect. These are done with primary emphasis on improving understanding of the structure of intellect. As such, the aim is scientific knowledge and the research might be thought of as basic. If you want to predict success of people in various activities, and if you had a complete inventory of the structure of intellect, you could apply your 20, 30, or 40 tests, and find out which ones would predict success in this particular activity.

At the other extreme, a completely applied approach makes use of the miniature job sample. In this approach no analyzing of the job is done. There is no requirement to understand what is being measured. To determine whether a person will be a good airplane pilot with this approach, the test would include a miniature airplane and a stick and rudder, and the task would include the activities required of the pilot. The same thing has been done with the task of automobile driving. The miniature task is devised so that it doesn't require too much training but still seems to carry in it the whole task which is being predicted. Of course, one's success in identifying and including the important aspects of the job is quite important here.

From the practical point of view the miniature job sample approach isn't very satisfactory because there are too many jobs. If there are 1000 jobs, 1000 tests are needed and a lot of research and development work would be required to construct each of the tests. Furthermore, it would take too much of the individual's time to take a large number of these miniature job sample tests. Therefore, an intermediate approach has been developed somewhere in between the scientific study of the structure of intellect and the miniature job sample. This is based on the identification of job elements. (See Flanagan, Personnel Psychology, 1954.) These could also be called tasks or job components. Thus far, 21 such job elements have been identified and measures have been developed for each of them. It is hoped that as personnel people, psychologists, counselors, and others get familiar with these job elements they can look at a new job and say, "This job requires better than average table reading ability -- it requires at least average English expression -- it doesn't require coordination, inspection, or ingenuity," and so forth. (See Flanagan, 1957.)

The hope is that through making such judgments about jobs, and then following up to find out whether or not the individual's judgment was correct or incorrect, skill in making such judgments will be developed. There are now at least a half dozen psychologists who are working in jobs where they have to make many such decisions. For example, in the military services they get requests to select personnel for a new job. These psychologists make judgments based on a study of the job description and other available information about the job. They have developed a good deal of confidence which is backed up by a considerable amount of follow-up data that their judgment that a job requires tests 1, 5, and 13 in a battery of tests will be substantially correct.

It is hoped that as time goes on, psychologists will understand the nature of these job elements, recognize them in jobs, and be able to state with confidence the important elements in a particular job without carrying out either a comprehensive job analysis or follow-up study. The point will never be reached where checks on judgments will be unnecessary. A good deal of progress has been made, however, and more will continue to be made in this direction.

Ingenuity was selected as one of the job elements to measure. The procedure used in going from the stage of an identified and defined job element to a practical measure ready for validation is briefly as follows. First, the critical behaviors relating to the job element, in this case ingenuity, are used to develop a definition of the job element. This statement includes illustrations of ingenuity and also precisely those factors which differentiate an incident showing ingenuity from one showing reasoning ability. The second step is a psychological analysis of the nature of ingenuity. In this illustration the term "ingenuity" rather than "creativity" will be used because the job element being described appears somewhat narrower than creativity. The concept designated by the word "ingenuity" as used here, is differentiated from "creativity" and "productivity" as follows.

Productivity is shown by bringing forth many ideas and solutions. It emphasizes both quantity and contribution. This seems quite similar to the use that has been made of this term by most of the other participants in this symposium.

Creativity is shown by evoking something new into being. The emphasis here is on the newness and lack of previous existence of the idea or product.

Ingenuity is shown by inventing or discovering a solution to a problem. The emphasis in this case is on the existence of a problem and showing a quality of genius in solving it in an unusually neat, clever, or surprising way.

Thus, ingenuity is somewhat more narrowly defined than creativity and productivity. Perhaps in the long run, productivity is of most practical concern in a company, in a defense department, or in other types of practical activity. Creativity is a broad concept relating to bringing forth almost anything new in the way of an idea, a formulation, a model, a theory, or an esthetic or practical product. For present purposes, it appears desirable to concentrate on the more limited concept of ingenuity which will be operationally defined as including ideas, devices, and procedures which meet the following three requirements:

1. In order to be classified as ingenious, it should involve a practically useful solution to a real problem.

2. The solution must be a clever one, that is, it should be more than just satisfactory. It should be unusually fitting and clearly better than might be expected from the typical person working on the problem.

3. It should not be one that could be arrived at by a logical routine, or mechanical process, but should be novel in the sense of providing a surprisingly good solution to the special problems in the situation.

These factors resemble a definition of a patentable invention. Not every idea or device can be patented. It has to show some special qualities of unusual cleverness, utility, and surprise, or be especially neat or appropriate in order to qualify.

A solution can be regarded as ingenious if it meets the above three criteria regardless of whether it was thought of immediately when the problem presented itself, or whether it came after years of study and experimentation, was a "happy accident," or was a sudden incidental insight when the person's attention was focused on another problem. The degree of practical importance of the problem is not a factor in deciding whether something is ingenious. One can be ingenious when working on trivial problems as well as on important problems.

It is hypothesized that ingenuity is a trait which is relatively independent of other traits, such as reasoning and memory. It is suggested that although ingenuity can be increased somewhat with practice, individual differences are primarily the result of an innate quality of the organism which enables the person to make a rapid review of possible solutions and apply other knowledge to the problem situation even though it does not seem to have any obvious relation to it.

One of the advantages of this approach, of starting with a job element containing specific behaviors and moving through the psychological analysis is that others can review the basic thought processes, inferences, and hypotheses. Suggestions and disagreements can be stated quite specifically and definitely because the thought processes are explicit and not characterized by long leaps to conclusions based on implicit inferences which are not available for review.

It is proposed that ingenuity as defined above can be measured directly by providing problem situations for which an ingenious solution can be found. It is hypothesized that the ability to "think of" ingenious solutions is fairly independent of the time requirements involved. The ingenious person confronted by a problem situation will be able to think of the clever solution very quickly, whereas the person lacking this quality will be unable to think of the clever solutions even if given a large amount of time. It is proposed that the difficulty of the items be controlled by varying the extent to which the problem situation is structured. In other words, by narrowing or broadening the field in which the examinee is led to look for the solution, the proportion of the group who are successful on the item can be reduced or increased.

Items included in an ingenuity test should present typical situations covering a variety of problems for which some individual has found an ingenious solution. The following six criteria should be applied to each item in a proposed ingenuity test to make sure that the item is measuring ingenuity, or at least includes the ingredients required for measuring ingenuity.

1. A clearcut problem should be presented for which an ingenious solution exists which fulfills the three requirements mentioned in defining ingenuity above. The solution to this problem should not be known to any substantial number of the persons being tested. That is, ingenious ideas are needed that are not known to those being tested. Obviously, if the solutions are known, the test is merely one of memory or recognition rather than ingenuity.

2. It should not be possible to derive the solution by deductive reasoning from the facts given in the statement of the problem.

3. The individual must be required to "think of" the solution rather than recognize its applicability or superior quality from a list of possible choices.

4. The statement of the problem should not be such that it defines a particular word or concept so completely that the item is, in fact, merely a vocabulary item of the type where the definition is presented, and the word asked for.

5. The problem situations should be presented in such a way that detailed knowledge of the specific field is not required in order to think of the solution.

6. The key word should so obviously provide a pat and unique solution to the problem that the examinee experiences a definite feeling of closure. The solution should give him a definite feeling that it "clicks" or "snaps into place," so that the moment he recognizes that a choice is given which corresponds to this solution, he accepts it and goes on to the next problem.

Some examples of items developed to meet these criteria are given. The general format consists of a description of a problem situation. The ingenious solution of this problem is then stated, except that at the end or near the end, one, two, or three key words are omitted. In order to make the test machine scorable, the first and last letters for five sets of key words are given as the choices. The second and last letters, or other combinations could be used, but it appeared from the tryouts that the first and last letters worked well and did not introduce spelling ability as an important factor.

The procedure of limiting the answers to words which fit into the five sets of first and last letters shown avoids most of the difficulty produced because some examinees may think of other clever solutions. If the person being tested thinks up a different ingenious solution to the problem than the one on which the item was based, it is almost certain that this other solution will not fit any of the five choices given, and will warn him that this is not the one which the test authors had in mind. It is believed that the truly ingenious person will then be able to think of other clever solutions to the problem including the one around which the item was written.

To illustrate the application of these criteria to proposed ingenuity test items, some examples will be given. One example is as follows:

> "As part of a manufacturing process, the inside lip of a deep cup-shaped casting is machine threaded. The company found that metal chips produced by the threading operation were difficult to remove from the bottom of the casting without scratching the sides. A design engineer was able to solve this problem by having the operation performed
>
> A. i----p h--h
> B. m----n c--e
> C. f----r w--l
> D. l----d b--k
> E. u----e d--n"

The two words which provide an ingenious solution to this problem are the words "upside down." This corresponds to the letters given in choice E.

Another ingenious solution to this problem might have been to use a powerful magnet. The person taking the examination who thinks of a magnet as the best solution to the problem will find rather quickly that none of the choices given fits the magnet solution. He will then be encouraged to think of other types of solutions.

The test is based on the assumption that the test authors have collected a representative sample of problem situations for which others have found ingenious solutions.

The problem in the example given meets the six criteria listed above.

1. It presents a clearcut problem for which the solution would not be known to most of the people being tested. The solution fulfills the requirements included in the definition of ingenuity because it is a useful solution to a real problem. It appears to be clever, unusual, and not routine. It also has an element of novelty and surprise.

2. It is not possible here to derive this solution from logical procedures.

3. The individual is required to "think of" the solution rather than recognize it.

4. It does not appear to be a vocabulary item. There is not enough of a definition presented to give the concept of "upside down."

5. No detailed knowledge of this kind of job is required; it merely requires a little bit of ability to visualize this situation.

6. It does seem to evoke a certain amount of closure. The examinees feel that this is a good solution and they don't continue to search for another solution once having spotted this one.

Another item will be used to illustrate how one might modify an item to vary the difficulty or to make it a vocabulary item, or to make sure it meets all six criteria. The item is as follows:

> "A very rare severe wind storm destroyed the transmission tower of a television station in a small town. The station was located in a town in a flat prairie with no tall buildings. Its former 300 foot tower enabled it to serve a large farming community and the management wanted to restore service while a new tower was being erected."

Let us consider several possible next sentences leaving out one or two words and noting how varying the structure of this sentence varies the nature of the test item. The next sentence as used in the test was:

"The problem was temporarily solved by using a ______________."

The correct answer in this form is "balloon." Notice how this item can be made a little easier by saying:

"The problem was temporarily solved by attaching the antenna to a _________."

By including a little more structure and narrowing down the area in which the person must seek an answer, the difficulty of the item is reduced. Thus, if it turns out to be too difficult, it can be made easier by narrowing the range to make it clear that the solution involves the antenna, not increasing the power, or some other type of consideration.

Of course, the item would become not an ingenuity item, but a vocabulary item if the last sentence was:

"The solution to the problem was obtained by attaching the aerial to a large bag inflated with hydrogen, called a ____________________."

It is essential that the omitted word or words contain the core or the germ of the ingenious idea; otherwise, the item does not measure ingenuity. For example, suppose the last sentence was:

"The problem was solved by using a balloon filled with ______________."

This could have the word "hydrogen" as the keyed answer. In this form it would not appear to be an ingenuity item. The ingenious element in this item is "the balloon," that is, thinking of the idea of using a balloon here is ingenious.

The successful ingenuity item arises from stating the problem and structuring the situation not too much and not too little, so that it is possible to leave out one, two, or three words near the end which will contain the real essence of the ingenious solution. At the present time, a 24 item ingenuity test for use with high school students has been developed as part of the Flanagan Aptitude Classification Test Battery. This test requires 24 minutes -- 12 minutes on the 12 items in Part I, and 12 minutes on the 12 items in Part II. Ninth graders average about nine correct; twelfth graders average about 12 correct in the 24 minutes.

Two experimental forms were used to develop these 24 items from an original set of 40 experimental items. These items cover a broad range of situations. There are items on scientific experiments, on office procedures, on advertising, on mechanical problems, etc. Each problem situation has been selected as one for which someone has "thought of" an ingenious solution.

What, then, is the present status of this test? Does it really measure ingenuity? Unfortunately, a definite answer cannot be given to this question. It is believed that this approach -- careful, logical analysis, use of detailed rationales, and writing items which fulfill various specific criteria -- should result in a more valid test than could be expected to arise from the more typical approach to developing an ingenuity test.

At the present time, we have a limited amount of empirical data. The test has been given to the research staff of the American Institute for Research (approximately fifty members). Each member of the group provided peer ratings on all of the others whom he knew sufficiently well to rate. These peer ratings were on "ingenuity," "reasoning ability" (critical thinking), "ability to write reports," and "ability to plan and schedule research."

Each member of the group took four tests designed to measure these four job elements. The tests were prepared for the high school level. The average for the group was a little better than 22 of the 24 items right. There were, therefore, quite a few perfect scores and only a few individuals whose scores were not close to the top of the scale. There were some people who had rather high reasoning ability and rather low ingenuity scores, and also some for whom the situation was reversed. The discrepancies seemed to agree with our observations of these people. Some individuals were found with high vocabulary, low reasoning, and low ingenuity scores. The correlation between the peer ratings for ingenuity and scores on the Ingenuity Test was .30. The correlation in the high school group between the Ingenuity and Reasoning Tests was .50. Since the reliability of both these tests, Ingenuity and Reasoning, was about .85, it appears that quite a bit of the variance is unique. This latter criterion is the primary basis for adding a new job element to the battery. It must have unique variance which is included in the reliable variance as indicated by the reliability coefficient and which would not be predicted from the other 18 tests in the battery.

Job elements are defined so that the correlations will be as low as possible, thus providing an efficient battery for predicting success in various jobs. A number of validation studies have been planned and considerable data will have to be gathered before it can be said with confidence that this test is measuring ingenuity. Similar empirical studies will be necessary to determine the importance of the type of ingenuity measured by this test for success in scientific work.

Q--I was wondering if you could isolate elements of a job and consider them by themselves?

S--Yes, I would say that ingenuity on the part of a clerk and ingenuity on the part of a scientist working on a very important problem are the same. Coordination on the part of a butcher and coordination on the part of the surgeon are the same. They have different consequences, but both involve coordination. Inspection is important for the dentist in looking at an X-ray plate. It is also important for a factory person who is looking for flaws. These have very different practical social implications and social importance, but it is the same job element, and the same tests will predict success in reading the dental plate as will predict success in spotting the flaw in the casting as it goes by.

Q--One of your requirements was that these items not involve reasoning. I'm wondering if some of them at least don't do just that. For instance, we might ask of the first example you gave: "What are the ways of removing metal from things," and then go through the list of all the ways we know, and we are bound, if we are at all resourceful, to come upon the magnet and there may be others. Wouldn't this be a matter of reasoning?

S--I don't think so. I'd say that's simple memory. If you list all the ways you know, you're not using any reasoning, you're just relying on your memory.

Q--But you use your reasoning to make use of the memory data. Don't you use reasoning to say "this will work and this will not?"

S--Well, I guess to some slight extent you do. When you apply the test -- will this work? I guess you are using some elements of reasoning.

Q--I wonder if the suggestion that what really is in question here isn't the removal of a block. In all of these cases you have something farfetched enough that most people won't be able to fetch it. That is, there will be a block of their mind because the mind will tend to think of the cut upward and will not turn it over and therefore that precludes thinking of the draw of the earth. I wonder if that item might be improved to rule out the magnet, simply by saying that the thing that is being cut is made of plastic.

S--Yes, or some other non-magnetic material. I think a good deal of care needs to be taken with such items to try not to handicap the person with some knowledge.

Q--Where is it possible to get a list of these 21 job elements?

S--The 21 job elements are listed in this reprint on the Flanagan Aptitude Classification Tests, which is reprinted from the April 1957 Personnel and Guidance Journal.

Q--I would like to ask how you validate these tests? You talked about peer ratings. And one of the questions I have with regard to that is: Do you have as much care taken in the peer rating of ingenuity as you have in the definition of ingenuity?

S--The most important factor in leading us to this very careful step-by-step rationale is the problem that we can't get good criteria. And, since you can't get good criteria in many situations, you try to be as sure as possible on logical grounds that you are measuring the right thing. This is especially important in some situations where you have to use the test before it is adequately validated. If we didn't use any tests until they were adequately validated, there wouldn't be much testing going on.

Q--I'll admit that, but I'm still trying to find out how you would validate it. By construct validity or what?

S--I would say by all of these. Our specific operational plans are:

1. To use an intermediate criterion consisting of problems something like those used in the Ingenuity Test but without structuring the solution at all. They would write an essay solution and the solutions would be evaluated. Such a test is very expensive to score, and very time consuming. The test is not very reliable unless it is very long, whereas the objective test requires just 24 minutes.

2. We will try to get some kinds of ratings of the sort that Don Taylor used, or the kind that some of the other people reported using -- scales or peer ratings -- or the sort of ratings that Lindsey Harmon reported, so that we could say after ten or twenty years perhaps, that this person has really produced a lot of good ingenious ideas and made important contributions in the field, and this other person hasn't. I think within a small staff you have some opportunities for getting peer ratings that do have validity.

The present Ingenuity Test does seem to have a substantial amount of built-in construct validity. Although the problems of getting a satisfactory criterion measure for ingenuity are substantial, we do plan to initiate immediately some concurrent validity studies using a wide variety of groups. We also plan to get long range predictive validities by testing high school students and following them through college and into their careers.

THE NEEDS FOR ORDER AND FOR DISORDER AS MOTIVES IN CREATIVE ACTIVITY

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S--In Webster's Dictionary the primary definition of order is given as "the regular disposition or methodical arrangement of things; harmonious relation between the parts of anything; the desirable condition consequent upon conformity with law; absence of confusion or disturbance." Disorder is defined as "the want of order or regular disposition; immethodical distribution; confusion; neglect of rule; irregularity." A secondary definition of disorder refers to "discomposure of the mind; turbulence of the passions." Among the synonyms listed are "irregularity, disarrangement, confusion, tumult, disease." For the verb, to disorder, these synonyms are given: "to disarrange, derange, confuse, discompose, disturb, ruffle."

These dictionary definitions reflect accurately the common usage of the terms order and disorder. To consider an example from daily life, if an adult enters a room in which children have been playing, he is likely, upon thinking of the adult-arranged furniture before the children got there, to say that the room is now in disorder. In abnormal psychology we are accustomed to think of a mind as disordered if there has occurred a substantial suspension of the laws or expected regularities which characterize the functioning of the mature ego. We consider a polity to be in disorder if the authority of the government is not respected by a great majority of the people and if civil anarchy replaces regulation by law.

In all these instances, the word order is used to communicate some sense of a norm which is desirable, and the word disorder implies an undesirable state of affairs from the point of view of mature social functioning. Considered outside such a normative context, however, it is apparent that the states of affairs indicated by the term disorder are themselves a form of order, the principles of organization of the given state being, however, not readily recognized or assimilable to the attributes of order which our intelligence in its function of adaptation to external reality has gradually evolved. The room which is "in disorder" is in perfect order if one considers furniture in terms of objects for disposition in the play of children; the disordered mind is in perfect order if one can discern the psychic forces which are "at play" when the governing function of the ego is put out of commission by an aberrant biochemical state or a psychic trauma; the disordered polity is in order if the historical and economic forces which generate revolution, that is to say, an overthrow from below of the hierarchy of authority, are understood. In one of the more common pieces of psychological jargon current in hospitals for the mentally ill, it is often said of a patient that "his affect is inappropriate." What is meant is that the existing affect, which reflects one aspect of a highly ordered state of affairs, is not understood in its context. In brief, the term disorder is by almost universal agreement used to refer to a state of order whose principles of organization are not clearly articulated in the framework of the most commonly adopted perceptual schemata, with the implication that this absence of common regularity is highly undesirable.

When one turns from the conventional construction of the term disorder, however, and asks how disorder is construed by individuals who turn out original work in science or art, a startling reversal of the usual understanding of and attitude towards apparent disorder may be observed. My own initial observation of this reversal under relatively controlled experimental conditions came with my research on preferences for varied sorts of abstract line drawings. The drawings I used were made in black ink on three-by-five-inch white cards, and they were varied primarily in terms of the degree to which they were drawn according to a geometric principle educible at a glance. The simplest forms were the straight line, the circle, the square, and the triangle. Complex polygons presented a somewhat less obvious geometrical principle of construction, and complex arrangements of curves, a still less obvious principle. At the other pole from the simple geometrical figures were drawings which appeared almost as childish scrawls or as totally disarranged configurations. When I asked subjects to describe these figures, they applied such words as regular, neat, clean, orderly, and static to the simple geometric figures, and such words as irregular, messy, whimsical, dynamic, disorderly, and chaotic to figures at the other extreme.

I was enabled through my participation in a study of doctoral candidates in a number of teaching departments in the faculty of science at the University of California to elicit expressions of relative degrees of preferences for these figures from subjects who had been rated by faculty members in terms of the originality of their research and their formulation of problems in their field. A correlation emerged in that study, and has been confirmed in subsequent studies, between rated originality and preference for the less simply ordered figures, i.e., for figures which are generally seen as disordered, irregular, or even chaotic. The same kind of preference is shown to a marked degree by artists, and even among active painters a significant relationship has been found to exist between judgments in open competition of the originality of their work and their degree of preference for the apparently disordered drawings. In other studies this kind of preference has been shown to relate to independence of judgment when one is under pressure to conform to a false group consensus. In summary, a higher degree of acceptance of what is not obviously in simple good order characterizes persons who are independent in judgment and original in their thinking. This is a weaker form of the statement which I shall later attempt to show is the more accurate appraisal of the facts: namely, that creative individuals have a positive liking for phenomenal fields which cannot be assimilated to principles of geometric order and which require the development, or, better, the creation, of new perceptual schemata which will reestablish in the observer a feeling that the phenomena are intelligible, which is to say ordered, harmonious, and capable of arousing the esthetic sentiment.

Supposing for the moment that such a motive exists in creative individuals, how is one to account for its coming into being? There are two possible lines of explanation which seem to me to be directly relevant. The first of these argues from the selective adaptation of the central nervous system to the most immediately demanding aspects of external reality which organisms had to cope with in order to survive. In this view, the essential function of intellect is the ability to discern regularities so that destructive contingencies may be foreseen and avoided and constructive possibilities entertained. In other words, in the evolution of life, what was most necessary for the organism was that events be predicted so that self-preservative action could be made ready. The mechanism for achieving such an ability to predict is classification, or the perception of repetition and similarity. The intellect therefore seeks out in every situation that which is already familiar, so that the principle "like produces like" may be applied. The most abstract and far-reaching extension of this essential principle is embodied in the structure of science, which applies rigorous method to avoid error of observation and inference but which does not depart essentially from pristine common-sense in its goal, which is to discern repetition. Geometry enters as the purest form of this bent of intellect because it eliminates the succession in time upon which the inductive process depends and generates the perception of similarities, or conclusions imminent in the premises, by a set of rules for classification and inference. It too, then, partakes of the earliest established mechanism for adaptation to external reality in its search for repetition and its reliance upon classification.

In contrast to this adaptive mechanism, which depends upon a static cutting-up of time and space into clearly bounded intervals, the evolution of life itself is seen as occurring in real duration, which is an unanalyzable flux, a continuous and invisible progress indefinitely pursued in which the determinative factors can be seen only in retrospect and the developing forms of which are unforeseeable simply because prediction depends upon repetition and life continually produces novelty. The creative intellect, in this view, is that which is ready to abandon classifications known from the past and to acknowledge in its strongest form the proposition that life, including one's individual life, is pregnant with unheard-of possibilities and may be the vehicle for transformations without precedent. When such a possibility is accepted, the coercive power of all known systems of classification and the predictive value of regularities based upon a history of repetitions are set aside in favor of an openness to the forces of life which are pressing for novel expression both in one's individual existence and through it as a vehicle for the creation of an unforeseeable future. Thus, in those individuals whom in retrospect we identify as the bearers of the creative impulse in our generation there appears a positive preference for what we are accustomed to call disorder, but which to them is simply the possibility of a future order whose principle of organization cannot be told now.

The question remains, what has made the particular individual the bearer of the creative impulse? By way of a partial answer I should like to invoke a retrospectively noted repetition. It approaches banality to remark that the creative artist and scientist appears, when one reads biographical accounts, to have experienced an unusual amount of grief and ordeal in life and to have shouldered burdens of pain that most commonly disable the individual for any constructive participation in the human community. In many instances such an individual is, in fact, periodically disabled or comes finally to a fate as grievous as his beginnings. Thus arose the theory which gained such currency in Europe during the 19th century, and which has hoary precursors, that genius is closely linked to pathology. Accepting for the moment that the correlation so generally noted actually exists in nature, how might one account for it in a way which would link the facts to the theory of creative evolution? I suggest that the creative individual is one who has learned to prefer irregularities and apparent disorder and to trust himself to make a new order simply because in his own experience he has been confronted with interpersonal situations which made prediction on the basis of repetition extremely difficult, but which by dint of effort and through the grace of unusual aptitude for accurate perception proved finally resolvable. Experimental facts established in the psychology of animal learning are relevant here. An organism deprived of the object necessary for reduction of a strong drive will, so long as the deprivation is not incapacitating, work harder to attain the object and will be more strongly reinforced, that is, will learn the path to the goal more readily and will retain the ability to make the desired performance for a longer time, than an organism which has received the same amount of the reinforcing object but under less strong drive or less intense conditions of deprivation. In the individuals whom we identify later as creative, I would posit a stronger initial impulse to render experience intelligible, combined with an unusual ability to pay attention and to organize percepts effectively for prediction, both of these factors being present in a situation which is exceptionally depriving in terms of intelligibility or its susceptibility to classification. The goal is finally attained or partially attained, however, with correspondingly greater pleasure upon the reduction of tension. The motive is thus generated for searching out other situations which would seem to defy rational construction, with some degree of confidence that after much deprivation, tension, and pain, a superior form of pleasure will be attained. What is learned, moreover, is that an unusual degree of reliance must be placed upon evidence which is not accorded much common acceptance, and that one must be extremely tentative in subscribing to the way of ordering experience which is in vogue among one's associates. Such an attitude is bound to lead to many "errors" along with many new truths, which is one of the reasons why the rest of us should suffer the creative individuals among us to be absurd as often as they need to be.

In the psychic life, the function which embodies most fully the adaptive mechanism which evolution has perfected most highly is conscious attention. Discrimination, memory, reflection, and judgment in the service of prediction are the marks of the ego. If one now considers the totality of psychic functions as a phenomenal field, then the part of that field which most partakes of order in the dictionary sense of the term is the ego, and those parts which have less apparent order in them are the preconscious and the unconscious. Turbulence and instability characterize the organization of ideas and impulses which are outside of conscious attention. The creative individual, in his generalized preference for apparent disorder, turns much more than do most people to the dimly realized life of the unconscious, and is likely to grant more than a usual amount of respect to the as yet unconfigurated forces of the irrational in himself and in others. Again to begin with a weaker form of the statement I believe to be most accurate, this respect consists in a faith that the irrational itself will submit to some ordering principle if it is permitted expression and subjected to conscious scrutiny. To put the matter more strongly, I believe that the creative individual not only respects the irrational in himself, but courts it as the most promising source of novelty in his own thinking. When such admissibility is granted to the ordinarily tabooed thoughts and impulses which have undergone an earlier repression in the interests of immediate adaptation, the individual may at times appear to others to be unbalanced. The unbalance which comes about in such a fashion is, however, according to my view, essentially integrative, and as such is health-tending.

The creative individual is one who not only attempts complex solutions of problems external to himself through special attention to and preference for apparent disorder, but attempts also to create himself through commitment to a complex personal synthesis. In the most elegant of cases, this synthesis involves a tremendous interpenetration of symbols drawn from the individual's sexuality, his philosophy, and the meaning of his work, with complex overdetermination of actions and feelings which are themselves expressively simple.

From all these considerations a general framework of hypotheses concerning creativity may be stated. The reflections which have formed the basis of present research into creative thinking in science and in art at the Institute of Personality Assessment and Research have led to the following formulation:

1. Creative people are more observant, and value accurate observation, truth-telling to themselves, more.

2. They often tell or express only part-truths, but vividly, but the part they express is the generally unrecognized -- they point to the usually unobserved.

3. They see things as others do, but also as others do not.

4. They are thus independents in their cognition, and also value clearer cognition, so that they will suffer great personal pains to testify correctly.

5. They are motivated both to this value and this talent (independent, sharp observation) for self-preservative reasons (the ego-instincts at work).

6. They are born with greater brain-capacity -- more ability to hold a lot of ideas in their head at once, and to compare more ideas with one another, hence to make a richer synthesis.

7. In addition to unusual endowment in terms of the ego-instincts, they have much sexual drive as well (both pregenital and genital) because they are by constitution more vigorous organisms and more sensitive (nervous).

8. Their universe is thus naturally more complex, and in addition they usually have more complex lives, leading them to prefer much tension in the interest of the pleasure they obtain upon its discharge.

9. Hence, they also have more apprehensions of unconscious motives, fantasy life, etc. They note or observe their impulses more, and allow them expression in the interest of truth.

10. Creative people have exceptionally strong egos. The self is strongest when it can go far back regressively (to let primitive fantasies, tabooed impulses into consciousness and behavior) and yet return to a high degree of rationality. The creative person is both more primitive and more cultured, more destructive and more constructive, crazier and saner, than the average person.

11. When the distinction between subject (self) and object is most secure, the distinction can with most security be allowed to disappear for a time (as in mysticism and in love). This is based on true sympathy with the not-self, or with the opposite of those things which comprise defensive self-definition. The strong ego realizes that it can afford to allow regression, because it is secure in the knowledge that it can correct itself.

12. The objective freedom of the organism is at a maximum when this capacity exists, and creative potential is directly a function of objective freedom.

In conclusion, I suppose I should point out that the title of this paper is misleading, since it accepts the conventional and dictionary-endorsed definition of disorder and posits it as a motive, whereas from all I have said it is evident that I am thinking of the "need for disorder" as a need for a situation which cannot be ordered according to accepted schemata but which is likely to have an order of its own, though hard to apprehend. In brief, the creative individual is someone who has an exceptionally strong need to find order where none appears, and who as a result of his own abilities and personal experience honors the apparently unclassifiable with his consecrated attention.

Q--I am thinking that the creative person tolerates, enjoys, and, in fact, seeks a certain amount of disorder. Would it be correct to say that that is true only as long as he feels that it is possible to create out of that disorder some other order that is satisfactory to him?

S--Yes, but he doesn't have to be very sure. One essential requirement here is that the individual is able to make the unguarded leap, as it were.

Q--I'm wondering about the degree of disorderedness. There was only a certain range of disorder in your data. Supposing the range had been extended from much simpler to much greater disorder. Might we not find that there is a point in here beyond which your creative people would not go? They would not accept it because they are unable to make anything of it.

S--I think it is very likely. I once suggested an experiment which proved too costly to do but which would attempt to get at that. My thought was to combine music with experimental color films in which you can take a visual theme and simplify it or complicate it as you want. It is possible by this combination to produce a set of sensations, visual and auditory, such that they are almost unbearably disordered. I think if you could arrange the apparatus so that the individual (subject) could indicate the point at which the disorder became unbearable, such as by pushing a button shutting it off, that you could extend greatly the range of the test of tolerance of disorder. But to return to your question, are you thinking, perhaps that there is some point of efficiency such that if one allows too much chaos to impinge without introducing any hope of order that that is no longer effective and no longer creative? I think you are probably right. I suspect that in schizophrenia, for instance, this is what occurs. The conscious self is overwhelmed by what is ordinarily unconscious, and the individual is totally incapacitated by being flooded with that which is generally repressed in the interest of effective action. It is quite evident that a flexible repression mechanism is essential for any kind of adaptation. In other words, this is a quantitative matter, and I think it would be true that one could go too far in courting disorder.

Q--I'm trying to toy with two or three things at once. Going back to the present state of things, whether it is much of an explicit scheme or not, at least it could be often thought of as some kind of a scheme or system, whether society is recognizing it as such or not. Is the creative person not making a choice in each case? The disordered state is preferred to the ordered one when he is seeing things which the other people are not seeing.

S--You mean he has a bit of a head start in making order out of the current disorder?

C--No, not exactly. He is making a choice each time between what is currently accepted by others as a state of order, which he sees as somewhat a state of disorder, and another state of at least temporarily much greater disorder if he should abandon the currently accepted state. Then I am wondering how this goes with the calculated risk concept. Is he making a choice partly in terms of the calculated risk that he can go a new way and ultimately come up with an order which is sufficiently better than the currently accepted state of order?

S--I'm inclined to believe that if the ego is sufficiently strong it does not allow itself to regress without the confidence that it can correct itself and can handle whatever it undertakes. In other words, I think always some economic law is obtaining here in the psychic life and that the creative individual is able to gauge much better how far he is able to go in permitting regression and perceiving disorder.

C--He is expressing a dissatisfaction with the present system because there is something he is sensing that others are not sensing. He, maybe alone, sees it as disordered.

S--He allows himself to sense more of it. One of the things that this variable, when high scores represent preference for disorder, correlates with negatively is the Hy scale on the MMPI, and it correlates positively with the Sc scale. This has been pretty consistent over several samples.

C--In one sense it could be said that he is not preferring a state of disorder over a state of order, but he is preferring one of two states of disorder.

S--Yes, he is preferring that which is more challenging, perhaps, in view of his own aims.

C--I find this report very persuasive, but I simply cannot fit about half of it to scientists whom I know well from my intensive studies. It would fit mostly the painters. A great deal of it just doesn't fit, particularly the biological scientists. They are very real and overwhelmed in the desire for rationalization, which is truer of them than it is of the theoretical physicists, although it is also somewhat true of the experimental physicists. My feeling there is that the experimental physicists can tolerate disorder. What they like is a little disorder on the fringe so that they can spread the order to bring everything into a total picture. This is characteristic, and this is all right with the biologists, too. The theoretical physicists are freer on this. About some of your other statements, I agree with the strong egos, in general, and with the strong need for understanding, if you were thinking in Maslow's terms. But with the degree of freedom of unconscious drives and accessibility of the unconscious to the conscious and tolerance of this, I cannot agree with the signs -- in general, I would say that this is not the case.

S--Well, perhaps it depends upon what level of creativity we are talking about.

Q--Could it be that the scientists you observed were unable to tolerate the unconscious but are still much more able to do this than the average person?

C--In general, I would say that some of them made use (not deliberately) of their involvement in their scientific problem to prevent the entrance into consciousness of many of these primitive drives, and this was quite effective.

S--It depends, though, on whether you consider that the unconscious impulse may find expression in symbolic form. Again, I think what happens often is that the ordinarily repressed impulses get expressed without insight in the ordinary sense.

C--This is undoubtedly true but I thought you were making a point that there is more conscious awareness, that they were more open, more tolerant of conscious awareness of primitive drives.

S--Not in the "psychological insight" sense. It is not awareness but expression and action.

C--I don't think that is always true but I would certainly go farther with that than with this awareness.

Q--This brings up a question about the cosmos of meaning and the universe of meaning. What I think you have said is that the creative person's only means of knowing and being in full is through both order and disorder, the disorder which lays open the plenum of possibility and then closes it up in a configuration which satisfies his sense of a full waking import. The question then is "What is the creative person's relation to the whole universe of meaning which comprises the area in which he is expert in making configurations?" (Or to the whole cosmos of meaning, and there I think we have something nearer to the artist, which includes perhaps many kinds of universes and perhaps excludes some, too, because the artist is often no good at mathematical formulations, etc.) It seems to me that some people take responsibility very definitely for one universe of meaning, as the scientist does, and are sometimes rather incompetent in managing, or certainly not very fresh in managing, activities in other areas. The great genius is likely to be so deeply motivated that his whole impulse will partake of a sense at least of the total human need, the total configural necessity, that is, the total pattern that is needed by man in order to be what man may be in his best possibility in so far as we may guess it or intuit it. Does this seem to fit?

S--Yes, I think so. When I referred to the bearers of the creative impulse in our generation, actually I was thinking of about half a dozen people. This formulation, I think, would be less true of scientists of a lower level of creativity, but I believe that it would be true of both scientists and artists of a very high level of creativity. There the making of a cosmology is the enterprise, actually, of the extremely creative person.

C--If we take a look at the arts and try to answer the question, why should the human race over the centuries evolve these particular forms in which to engage themselves and call these creative, perhaps there is a cue, it seems to me, in that each one of them comes to a place of maximum ambiguity. The painter starts with only a flat white canvas and the sculptor will start with a stone or a wholly ambiguous clay, etc., where there are maximum potentialities within the great range of ambiguity, and he has to treat this for the potentiality. If you ask why the race should come to these forms in which to engage itself fruitfully, then it would seem that one of the principles is that he has got enough there but not too much. It would seem that in some human areas we have a little more than we can handle.

S--I think that one sign you would look for if you were trying to determine whether a scientist is likely to work creatively is whether he chooses problems whose implications are such that they can affect a large structure. That is, the very choice of the problem which has most possibilities in it of leading to something really important is a sign of a potentially creative mind.

C--In trying to understand your paper it would be helpful to me to ask why, since you derive your formulation from observations of people at a relatively low level of creativity, you have extrapolated to the half dozen most creative people you could think of? Those are the ones who would be described of this formulation. They would be very rare birds, so to speak.

S--I think of the rare bird in this instance as a distillate, so that you can see in purest form what is happening. I think you get lower correlations if you deal with less crystallized personalities. If you are essentially looking to process by way of the correlational method, you are always going to get a muddied picture. My formulation undoubtedly goes beyond the data.

C--You have to use a lot of people to distill it out but you haven't that many people.

S--If you do arrive from the correlational picture at a formulation concerning process, I think the test of it is in those individuals who are the highest representatives, as it were, or the most fully developed forms of it.

C--That helps, because I couldn't imagine some of the people described by Harmon this morning as being like this.

C--I can't resist asking about the nature of your special project on the nature of creativity in women. Is this on the assumption that you need a different theory there?

S--I find that there are two groups of people who react negatively to our hypotheses in that study -- men and women. While we credit the social-role kind of determination of choice of occupation by women, we do not credit it nearly so highly as do many of the people who argue against the biological-function kind of theory. One controversial finding we have had in previous studies of men is that quite consistently on a series of inventory measures of masculinity-femininity, originality in men is correlated with feminimity. Our notion is that the social conditions which in the past may have inhibited women from producing a high order of creative work are being changed, and that within the next few generations there should be a great emergence of women in the field of arts and science, if there are no basic constitutional differences in originality between men and women.

C--You did not say if the reverse correlation was true, whether women who are high on creativity are also high on masculinity.

S--Well, I venture to suggest that they must be, but we don't have any evidence as yet.

C--We have a finding that is a little paradoxical in our studies of problem solving. We have been interested in some of the non-intellectual determinants in achievement in solving logical problems. In a paper which will appear shortly in the Journal of Abnormal and Social Psychology by one of the persons working with me, we found on a large population of undergraduate men and of undergraduate women that when we control, by partial correlation techniques, for differences in intellectual ability as measured by various tests, that there was a significant positive correlation, both among women and among men, between success in problem solving and degree of masculinity, as measured by any of three masculinity measures.

S--Is it possible that this correlation I am reporting is not a sound one in general because the test materials emphasize verbal abilities. But we have done a sex difference study on the Unusual Uses, Consequences, and Plot Titles tests, and while we find sex differences in kinds of responses, we don't find sex differences in total score.

Q--What kinds of logical problems were you using in your study that you mentioned?

Q--I gather that you are worried whether the content of the problem favored men?

C--No, I was thinking that possibly you were dealing with convergent thinking and he was dealing with divergent thinking.

C--Yes, I think there is a real difference there. Ours were convergent, in your terms.

THE MEASUREMENT OF CREATIVITY IN MACHINE DESIGN[1]

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S--Despite what is now its clearly apparent social importance, psychologists have thus far devoted relatively little time to the investigation of creativity. That work which has been done may be assigned to three broad categories for purposes of review.

First, both necessarily and conventionally, a substantial proportion of what has been written is primarily descriptive, speculative, or intended to stimulate research. Prominent among recent publications of this character are those of Guilford on creativity, Thurstone on creative talent, and Osborn on applied imagination. Less recent, and somewhat less directly relevant to creativity, are such familiar formulations as Dewey's description of the steps in the problem-solving process, the Gestalt schools' explanation of insight learning in terms of the reorganization of elements to form new and meaningful wholes, and Spearman's identification of the ability to educe relationships with the highest form of cognition.

Second, there is a type of investigation, germane to creativity, which has as its focus increasing the supply of potential talent, either through appropriate training or through the discovery of conditions optimally conducive to the problem-solving process. For example, Donald W. Taylor is the present leader of a broadly conceived program of this type; and Calvert et al., have recently been concerned with a project specifically devoted to the area of engineering problems.

Third, there is a class of studies in which primary emphasis has been placed upon the identification of individuals possessing outstanding potentialities for creative work. Prominent among these is surely the comprehensive program of Guilford and associates devoted to the development of measures, and to the factorial description of various patterns, of "high-level aptitudes." It is hypothesized that one of these patterns characterizes the creative individual, although it is also recognized that there may be several types, and thus several patterns, of creativity.

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[1] This research was reported by W. A. Owens and was done under Contract Nonr-530(02) between the Office of Naval Research and Iowa State College; however, the opinions and assertions contained herein are those of the writers and are not to be construed as official or representing the views of the Navy Department or the Naval service at large. Permission has been granted by the Journal of Applied Psychology to reproduce the above article, the main portion of which appeared in the Journal of Applied Psychology, Vol. 41, No. 5, 1957, 297-302.

Within the broad field of engineering, Harris and Simberg, of the A. C. Spark Plug Division of General Motors, have developed what seems to be a very promising test of Creative Ability, although to the knowledge of the writer, the only report on their work to date, excepting an abstract by Harris, is contained in the Examiners Manual for the test. Conspicuously present here is some encouraging preliminary evidence as to validity.

The present study, involving a highly specific criterion, was initiated because it was recognized that the United States was critically short of creative machine designers during World War II, and that an alarmingly small proportion of those present were either native born or the products of American Schools of Engineering. It has two phases -- one concerned with the concurrent validities of measures applied to various industrial groups, and a second directed at discovering the predictive value of the same measures already applied to over 1,500 students at 24 colleges and universities. The present report concerns the first phase only.

Purpose

Accordingly, the formal purpose of this investigation was to develop, and to evaluate, tests for the discrimination of creative from noncreative machine designers.

Methods

Limitations of space do not permit a detailed description of all aspects of the methods here employed. However, since many of them are familiar and clearly implied, only those which are central or somewhat unusual will be emphasized. Where more complete information is desired, it may be obtained from the Examiners Manual for the present tests (see Owens et al.), or by direct communication with the senior author.

Overview

In brief, this study involved the construction of nine measuring devices which were item-analyzed and cross-validated against a primary criterion of the rated creativity or noncreativity of 295 engineers in 31 industrial firms.

Hypotheses

The following structuring hypotheses were formulated subsequent to the interviewing of a number of creative engineers and an examination of the literature, but prior to the actual task of test construction:

1. It was assumed, because of restriction at a high level, that differences between creative and noncreative machine designers are not primarily attributable to general mental ability.

2. It was assumed that constructive, high-level aptitudes or abilities cannot surely be fairly appraised with recognition-type tests, and that those constructed should be primarily of the completion type.

3. It was assumed that differences between creative and noncreative could not be fairly attributed to aptitude unless age, education, and relevant job experience were controlled.

4. Since the organization of creativity is incompletely determined, it was assumed to be "specific," the safest assumption, and measuring devices were restricted to areas of some felt machine design relevance.

Measuring Instruments

The devices themselves may be briefly described as follows:

The Power Source Apparatus Test.[2] The S is given a power source and a motion sequence and is to sketch as many intervening mechanisms as possible. The scores are for absolute number and number "workable," with the workable solutions categorized and weighted for discrimination (8 items).

The Design a Machine Test. The S is given a particular purpose to be served and is to sketch as many appropriate mechanisms as possible. The scores are for absolute number and number "workable."

The Applications of Mechanisms Test.[2] The S is given a particular mechanism and is to enumerate as many types of machines in which it might function as possible. The score is the number listed (7 items).

The Three Dimensional Space Relations Test. The S is to mentally fold a flat pattern to form a cube and then to indicate the positions of three of its faces following various patterns of rotation. The score is the number correct.

The Figure Matrices Test. The S is to derive the rules by which a figure evolves in two dimensions and to apply these in order to supply a missing figure at any given point in the matrix. The score is the number correct.

The Number Series Test. The S is to derive the rule or principle by which a series of numbers is generated and to apply it to supply certain missing numbers. The score is the number correct.

The Unstructured Test. The S is given a series of meaningless, incomplete "mechanical-type" drawings and is to indicate what they could be, how many different things can be seen in each, and to circle the relevant parts. The scores are for number of objects identified, number of responses per minute, number involving motion, number of line segments used in each response, number of machines identified, and percentage of machine responses.

The Personal Inventory.[2] This is a quasi forced-choice inventory,[3] originally of 197 items, which deals with interests, attitudes, opinions, personal characteristics and experiences. The score is the number of weighted responses typical of the creative machine designer; item weights are based upon amount and consistency of discrimination (50 items).

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[2] Retained in the revised battery.

[3] Precise preference matching was not attempted.

The Personal History Form.[4] This is a single sheet, originally of 48 items, which deals with personal background. The score is the number of weighted responses typical of the creative machine designer with all responses assigned to the same five-point scale and differentially weighted for amount and consistency of discrimination (8 items).

Only four of the above instruments survived item-analysis and cross-validation. These were the Power Source Apparatus Test, the Applications of Mechanisms Test, the Personal Inventory, and the Personal History Form. These compose the revised battery.

Subjects

The several samples of subjects, the batteries administered, and the pattern of cross-validation are indicated in Figure 1. It should be noted that the N's for all groups, except the Patent Index group, include both creative and noncreative components.

Criterion

Members of the primary criterion groups were defined as follows:

Creative designers are persons who have demonstrated the ability to comprehend the nature of a design problem, and to produce a novel, ingenious, or original solution in the form of a total, functional, and practical mechanism. Creativity, in this sense, does not necessarily involve the conception of an entirely new principle, but does involve the combination of existing principles or mechanisms in such a way as to produce a new and unique solution to a previously unsolved problem.

Noncreative designers are persons whose major function is to work out the details of a design; they are the engineers who do not produce original ideas, but who work out the routine problems of what materials to use, and who smooth out the design according to established procedures.

Industries were contacted to see if they had such individuals and if they could be tested. Where replies were positive, their supervisor, usually the chief engineer, was instructed to identify engineers who could be considered creative according to the definition, and to select a like number of noncreatives matched as nearly as possible for group age, education, and experience. Subsequent t tests on these matching variables revealed no difference significant at even the 5% level.

A secondary sort of criterion was obtained by mailing the self-administering measures (the Personal Inventory and Personal History Form) to a sample of 76 individuals revealed by the U. S. Patent Index to be creative, in fact, in the sense of holding a large number of patents (minimum 13 and mean 22 + for the period 1947 through 1951). Their responses were contrasted with those of the rated noncreatives for item-analysis purposes and it was noted, in accordance with expectation, that they were similar in direction to

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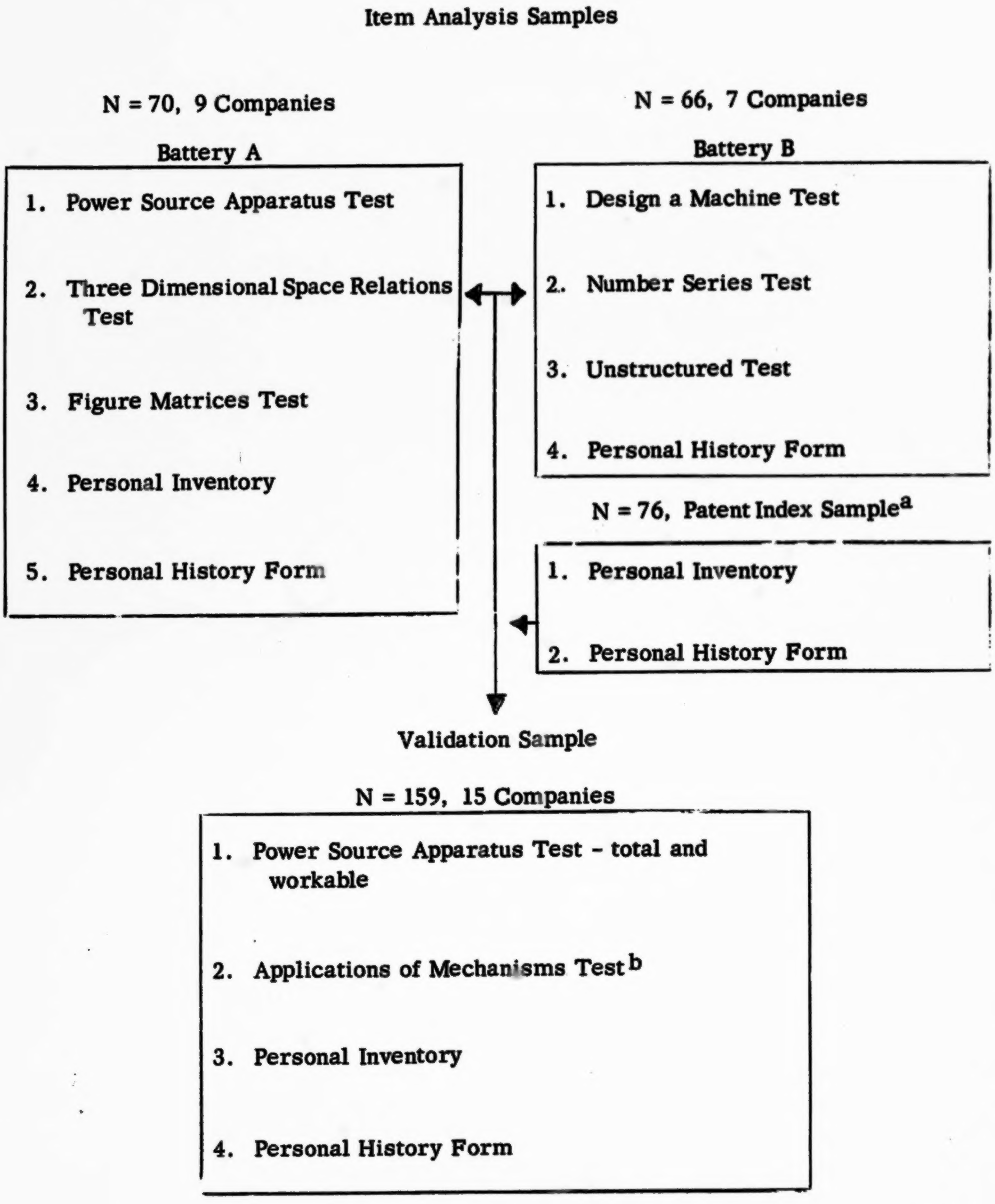
[4] Retained in the revised battery.

Figure 1. Samples, Test Batteries, and Pattern of Cross-Validation


Item Analysis Samples
N = 70, 9 Companies
Battery A
1. Power Source Apparatus Test
2. Three Dimensional Space Relations Test
3. Figure Matrices Test
4. Personal Inventory
5. Personal History Form
N = 66, 7 Companies
Battery B
1. Design a Machine Test
2. Number Series Test
3. Unstructured Test
4. Personal History Form
N = 76, Patent Index Sample[a]
1. Personal Inventory
2. Personal History Form
Validation Sample
N = 159, 15 Companies
1. Power Source Apparatus Test - total and workable
2. Applications of Mechanisms Test[b]
3. Personal Inventory
4. Personal History Form

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[a] Mean patents from '47 thru 51 = 22.6.

[b] Patterned after one, atypical P. S. A. item; cross-validated by splitting validation sample.

those of the rated creatives but that discrimination was sharpened by employing the Patent Index Group. Insertion of this P. I. group actually served a dual purpose -- it permitted some evaluation of the rating criterion and it made possible a modified and preliminary cross-validation of those measures potentially standing most in need of it.

Statistical Treatment

The data were treated by the application of such statistical techniques as the $\underline{t}$ test, chi-square test, point-biserial correlation, multiple regression, and discriminant function analysis. The following methods or applications are mentioned because they seem a bit out of the ordinary.

Item Selection

On the Power Source Apparatus Test, Design a Machine Test, Unstructured Test, and the Personal History Form, differences in the number of item responses obtained from creative and noncreative groups were evaluated through application of the $\underline{H}$ test, a test of the significance of the difference between ranks (see Kruskal and Wallis). The remaining tests and/or scoring methods were appraised through the use of contingency tables with border classifications of creative-noncreative vs. some categorization of item response (usually correct-incorrect). The 20% level of confidence was established as the critical level for item selection.

In addition to meeting the foregoing criteria, each item was tested for the existence of a so-called "company effect." Such an effect could be said to exist if the proportion of correct or diagnostic responses made by members of the creative group were not independent of classification by company. The chi-square test was employed to evaluate this effect, and Snedecor's computational method was utilized.

Test Selection

Before accepting a subtest for inclusion in the revised battery, following item analysis, the critical ratio described by Brozek and Tiede was applied to determine whether or not the number of items in the test which were significant above the critical (20%) level was greater than could be attributed to chance. Here, the 5% level was selected as the critical one for the inclusion of a subtest.

Results

The primary results of this investigation are summarized in the three tables which follow. Table 1 contains odd-even reliability estimates and intercorrelations for the revised creativity battery as it was administered to the validation sample. The tests are virtually unspeeded, so the tabled estimates of $\underline{r}_{11}$ should not be inflated. However, since the battery is to be used as a predictive unit, it seems more pertinent to observe that the subtest intercorrelations are relatively low. An exception is the high correlation between total number of solutions and number workable on the Power Source Apparatus Test. This may well raise a question as to whether both scores are necessary, the brief answer to which seems to be that even the former makes a marginally significant (5% level)

Table 1

Odd-Even Test Reliabilities and Test Intercorrelations

Validation Sample

	P.S.A. (T)	P.S.A. (W)	P.I.	A.M.T.	P.H.F.
Power Source Apparatus - Total					
Pooled[a]	.85	.89	.39	.51	.32
Av. Est.[b]		.84	.40	.52	.15
Power Source Apparatus - Workable					
Pooled		.83	.43	.38	.39
Av. Est.			.44	.38	.22
Personal Inventory					
Pooled			.66	.38	.23
Av. Est.				.42	.05
Applications of Mechanisms					
Pooled				.91	.38
Av. Est. (5% $\underline{r} = 0.16$)					.38

[a] Pooled = combined data for all companies.

[b] Av. Est. = weighted average of company by company estimates.

independent contribution to a multiple biserial correlation with the criterion.

There appear in Table 2 the point-biserial correlations between each of the several predictors and the criterion, utilizing both the pooled and the average estimate data. In addition, the summarizing multiple $\underline{R}$ is given at the bottom of each of the two columns. It should be noted that these R's have an element of spuriousness, since the estimated correlation of the Applications of Mechanisms test with the criterion is based upon only a split sample but was used as though based upon the whole. Nevertheless, whatever error is involved is of minor practical significance, since the multiple R's are dropped only a little more than one point if the Applications of Mechanics test is removed entirely.

Table 3 contains the data relating to the goodness of the classification job done by the present battery; these include the differences between the means of creative and noncreative groups ($\overline{X}_c - \overline{X}_{nc}$), the discriminant function weights and cutting score, and the percentage of correct classifications. The average estimate data are based upon standard scores, by companies to increase comparability. They are presented in only summary form, since it did not seem practical to introduce a table for each company. (The previous comment relative to the Application of Mechanics test applies here also.)

Table 2

Point-Biserial Correlation Between Predictors and Criterion Validation Sample

Test	Pooled	Av. Est.
Power Source Apparatus		
Total	.13	.20[a]
Workable	.26[b]	.33[b]
Application of Mechanisms[c]	.19	.36[a]
Personal Inventory	.17[a]	.21[a]
Personal History Form	.13	.21[a]
Multiple _R_	.38	.50

[a] 5% level.
[b] 1% level.
[c] Sample split.

Table 3

Mean Differences and Discriminant Function Weights Validation Sample

Test	$\bar{X}_c - \bar{X}_{nc}$	1
	Pooled Data	
Power Source Apparatus		
Total	1.4147	-.000170
Workable	2.5459	-.000011
Application of Mechanisms	5.8153	.000640
Personal Inventory	4.9667	.001872
Personal History Form	2.9118	-.001328
Percentage Correct Classifications = 66%		Cutting Score = .007612
	Av. Est. Data	
Full Battery, Percentage Correct Classifications = 86%		Range of Correct Classifications = 60%-100%

Interpretation

The percentage of cases correctly classified in Table 3 through use of the pooled data (66%) is an undoubted underestimate, since it is greatly attenuated by large company differences. On the other hand, the percentage correctly classified through use of the average estimate data (86%) is clearly an overestimate, since the discriminant functions themselves were not cross-validated, and since the number of predictor variables was relatively large and the number of cases within a particular company sometimes quite small. The writers are inclined to view the two values in question as crude bounds within which a high percentage of future estimates of accuracy of the battery in classifying "creatives" and "noncreatives" within a company may be expected to fall.

Implications

A question logically arises at this point as to how results obtained argue for the validity of structuring hypotheses. First, then, on the hypothesis that "creatives" and "noncreatives" are not differentiated by general mental ability, we have the following evidence. Three tests -- namely, Space Relations, Figure Matrices, and Number Series -- could be construed as measuring component intellective functions. In fact, none of these did discriminate the criterion groups.

Second, on the hypothesis that age, education, and experience must be controlled, we have only the evidence that this was done with considerable success (point biserial correlations = .01, .05, and .02, respectively), and that discrimination of the criterion groups was still possible.

Third, on the hypothesis that creativity is somewhat "specific" to the field in question, we have the following evidence. Of the six or seven ability tests involved,[5] three were quite specific to the area of machine design. Of these three, two are represented in the final battery; whereas, of the remaining three or four, none is so represented.

Theory

It seems an obligation to future investigators to attempt some clarification of two issues. The first relates to the essential nature of creativity in machine design; and the second to the promising leads for its measurement. The latter actually involve the "post-mortem" hypotheses of the authors.

On the first issue, it seems intuitively clear that, since the number of machine elements is finite, creativity in design must consist in finding new combinations or organizations of these elements. In addition, the new combination or organization produced must not only be "good machine design" in some absolute sense, but it must also serve some highly specific purpose. It may well be this latter characteristic, at least in part, which differentiates creativity in machine design from creativity in the domains of art or music or literature. Thus conceived, it is a problem-solving, goal-oriented, utilitarian sort of ingenuity which is of present concern.

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[5] The Unstructured Test is not easily classified.

On the second issue, it seems noteworthy that the associative process is tightly controlled in the test which makes the largest independent contribution of any in the present battery -- the Power Source Apparatus test. Here both the initial powering motion and the final motion desired are fixed. In "bridging the gap" the subject can utilize as solutions only those potential mechanisms which are adapted to both specifications. By contrast, the Design a Machine test, of job-miniature type, was a relatively poor discriminator. Here, with no really controlling restrictions or specifications, the subject was simply instructed to sketch a mechanism appropriate for a particular purpose. In broad perspective, it seems not unlikely that maximally discriminating ability tests in the machine design area must involve a highly structured context, even as the job itself involves one.

Shifting from measures of maximum performance to those of typical behavior, Jacobson has recently completed a Wherry-Gaylord iterative analysis of the items in the Personal Inventory. His results suggest that "asociability" and "egocentrism" are most important among the several clusters of characteristics which discriminate creative from noncreative machine designers. Verification is needed, but two measurement "targets" are tentatively presented.

Conclusions

1. A battery of four measuring devices for the discrimination of creative from noncreative machine designers has been developed.

2. The concurrent validity of this battery, within companies, is such that it would probably predict the correct classification of about three-fourths of the members of two equal groups of creative and noncreative designers.

Q--What sorts of items did you have on the personal history inventory?

S--Here are those which discriminated. They deal with education, childhood, hobbies and activities, and reading habits.

C--Your findings were much more in line with what one would expect than the ones Don Taylor reported with his biographical material, which were somewhat surprising to me.

Q--Which ones particularly surprised you?

C--Let's take it up later. (Laughter.)

S--Don has not yet had an opportunity to cross-validate his and perhaps some of them will drop out later.

Q--May I ask how you have thought through the kind of questions you would put in these personal history forms? How did you decide beforehand that this was a good question and that one wasn't?

S--That is a very excellent question. What we did is probably not too well revealed in this paper which has been compressed from about fifty pages to about eight or nine. We started out by collecting wire recordings of interviews with creative engineers; and we preceded this by backtracking to the academic records of the number who had been at Iowa State and satisfying ourselves as well as we could that general mental ability was not the critical thing. For example, we had in school a chap who came through with about a C+ average. In his sophomore year in college he developed a handkerchief vender which is fairly prominently displayed in public places around the country. He is now head of a laboratory in which a good bit of creative mechanical work is done. As a young chap he was not accepted very well because he had older people working for him. He answered this sort of threat by obtaining five or six patents per year and now they accept him quite nicely. With this sort of background and in terms of the hunches of creative people themselves and of the interviewers, we constructed the best items we could think of.

Q--Do I gather the point is that you selected items in terms of face validity and in terms of your experience from working in the area?

S--That's right.

Q--How do you know how to cast them? Anne Roe answered me earlier that she thought she had interview or open-ended kinds of items. How did you know when to leave them open-ended and when to turn them into objective, multiple-choice types?

C--You obviously get out of the open-ended business as fast as you can, because it's more difficult to handle such items, but I don't think that you can set up non-open-ended items until you've had enough open-ended items to find out what options are going to develop.

Q--How do you place these tests (like the Power Source Apparatus test) on this dimension from the miniature job situation through the job elements to the basic abilities?

S--I don't know. There are several things I could tell you here that might be interesting. It is, of course, a very vital question as to whether these tests are, in fact, achievement tests or whether they are aptitude tests. At the present time I have only the somewhat unconvincing evidence that in the educational institutions around the country where we were able to give the tests we got an occasional last quarter sophomore or first quarter junior who knocked off as many solutions as some of the patent index people. So there is an occasional untried individual who sticks his head up about as high as experienced machine designers do. I, therefore, would hope that there was some fair aptitude loading here, but your question is certainly a good one. You should perhaps know more about the administrative purposes.

The idea was that this test would be given in engineering colleges at the end of the sophomore year when people had substantially completed their didactic work and before they took off on engineering proper. It was to be used to identify a varying fraction, perhaps 10 - 25%, of individuals who might get special training -- somewhat less "pounding in" of the conventional material, and somewhat more of an opportunity to investigate unusual problems and to work independently. I understand that courses in machine design, for example, used to have one standard problem for everyone to solve. It was promptly handed down from generation to generation of fraternity houses and redrawn upon appropriate occasions.

To continue, then, there is clearly some background of familiarity with mechanisms or mechanical principles which is absolutely essential to performance on the Power Source Apparatus and Applications of Mechanisms tests. Hopefully, the premium on the background is not large. It seems that the items of the Personal History Form are based upon variables of some years standing, but of considerable specificity. On the other hand, the Personal Inventory is based upon characteristics of unknown recency but of no apparent specificity to the machine design field.

Age, like experience, also has some interesting correlates in these data. Older people tend to produce fewer solutions on the Power Source Apparatus test, but to produce a larger saturation of workable solutions within those given. One might speculate that, with age, one learns what will not work.

ULTIMATE CRITERIA FOR TWO LEVELS OF CREATIVITY

Brewster Ghiselin
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S--Investigation of creativity has been hampered by a most crucial difficulty: the very subject of investigation is ill-defined and elusive. There is as yet no settled agreement upon exactly what modes of behavior and what characteristics of products can with truly clear justification be called creative. In lack of adequate criteria, judgment has been guided by impressions, and by rationalizations of impressions, mainly proximate criteria, thoughtfully developed and employed, yet uncorrected by those ultimate criteria which alone could assure their validity. In short, discrimination of the creative from the uncreative, and of the more creative from the less, remains hardly better than guesswork.

The need for ultimate criteria of creativity is measurable in terms of the inadequacy of the proximate ones on which we now tend to rely. Among the proximate criteria most often resorted to have been the judgments of experts and the measurement of creative production in terms of published papers, patents, and the like. Estimates of creativity in men and their products have been more or less subjective or objective, ranging in this respect from the simple subjectivity of intuitive appraisal to the still simpler objectivity of numerical counts. The objectivity thus apparently achieved is delusive, for even in those procedures that may seem wholly objective, the count of published papers, for example, the items estimated must be judged to be pertinent -- that is, to represent creative work rather than some other sort of performance. Yet in absence of a sound criterion, the very judgment of their pertinence must rest upon assumption.

Some effort has been made to gain objective validity through applying highly explicit proximate criteria in multiple scoring of performers, performances, and products. In "A Proposal for Establishing Ultimate Criteria for Measuring Creative Output," presented during the 1955 Research Conference on the Identification of Creative Scientific Talent, J. H. McPherson suggested such a procedure, rigorously applied, as a means of establishing ultimate criteria. While conceding that "human judgment" is "the only gauge for measuring invention," he recommended a combination of proximate criteria in a scheme to be used as a single instrument in complex, analytical appraisal of products presumed to be creative. His suggestion was adopted in the "Report" of the Criterion Committee of the 1955 Conference, with explicit recognition that the more nearly objective criterion obtained through pooling many judgments is not really an "ultimate criterion" but is at the most "a close approach to one."

The clear advantage in using many proximate criteria together is that whatever distortion may be introduced by any one instrument incompetently applied or defective in itself will tend to be reduced. But the basic difficulty remains. Because these criteria all represent some form or refinement of human judgment ungoverned by ultimate criteria, the validity of all remains undetermined. In any case none of them can be more than a rule of thumb. Multiplying criteria, applying several together, we are still all thumbs.

We shall not have anything better unless -- or until -- ultimate criteria are established upon thoroughly rational grounds. The first requirement for this clarification is an acceptable definition of creativity. Even for intuitive judgment, the virtual equivalent of such a definition is required in an implicit form. Yet no such equivalent can be proved to exist, and therefore none can be credited, no matter how richly competent the mind laying claim to it or how profoundly sustained by faith in the validity of its subliminal processes.

There is no reason to doubt, however, that ultimate criteria for creativity can be established. An adequate definition of creativity should be obtainable through analysis of creative products in their intrinsic nature. Or, since the epithet "creative" really begs the question by presuming a discrimination among products on the basis of a criterion of creativity that has yet to be found or agreed upon, what really is required is an examination of products, in an effort to discover some grounds on which we can assign or deny to them the epithet "creative" in a fully intelligible and defensible way.

The products immediately relevant for investigation must be things physical or spiritual that have been brought into being by human agency. For our concern is specifically with the creativity of mankind and with the consequences of performance, of doing. Products of mere existence, passive or active, such as the heat developed by the body during rest or exercise, or the subjective glow in the consciousness of someone whose eyes turn to the sun, must be attributed to the agitations of nature rather than to the agency of man, and therefore may be described more accurately as natural productions than as human ones. They are, at most, contingent upon human action. And for the same reasons the accidental consequences of men's acts, such as crops grown from seeds carelessly tossed away, or floods produced by deforestation, must likewise be excluded from the category of strictly human productions. In developments of this kind, the human act is only a part of the complex of chance, any element of which is equally the producer of what befalls, whether fortunate or unfortunate, in the undesigned onflow of events.

Human production, on the contrary, circumvents mere fortune or misfortune, through imposing design upon substances and events, forcing on the casual order of nature a different order. Human products are developments shaped by operations of human energy intervening upon the sheer drift of things, animate and inanimate. They are formed by constraint of casualty, not by submission to it.

The joining of a stone to a stick to form an ax may serve as an example. If the object is formed by sheer accident, as through the chance lodging of a stone in a cleft club, it is not a human product. For then, although human fingers may have slipped the stone into place, it remains no more than a product of nature, part of the natural pattern of the world that is shaped and reshaped in the concourse of casual events. In human production the essential is an event that is not casual, namely a human agent's imposition of design upon the natural pattern of the world, subjective or objective. A human product is made, rather than evolved fortuitously. Stone and stick constitute such a product only if a human being brings them together to embody a pattern, a design.

Even when it comes spontaneously, in apparently unconscious action of the shaper, the human product has the aspect of a construction authorized by purpose. If, when something is produced thus spontaneously, there is any question about whether it is a merely natural product or a strictly human one, the shaper's attitude toward it must decide: it is a human product if he treats it as one, if he apprehends in its structure the determinations of his mind, if he sees it as the embodiment of his design. However fashioned, consciously or unconsciously, the products to be examined in hope of discriminating some that may rightly be called creative are all expressions of design; all are products of the mind.

We are sometimes inclined to include among the products of the mind all those concrete objects such as violins, rag dolls, potato chips, and cyclotrons, which differ from natural objects, like lightning, tears, or skeletons, in having been formed by our subjective realizations. Even those most material products of the hand or its surrogate the machine, that are made in the thoughtless course of routine manipulation or manufacture, snowballs or doughnuts or automobiles or other such objects, are in their origin and essence products of the mind, for all are structures of material assembled in conformity with subjective realizations. But the real products of the mind in all such objects are the subjective realizations themselves, which the material objects merely embody. It is obvious, for instance, that a machine punching out pie tins is only reproducing in materials a pattern that a mind produced earlier. In the strictest sense, the products to be considered in our enquiry are artifacts that define the order of consciousness: structures of meanings, formations of insight, ideas, images, or esthetic realizations. In short, the products of the mind are the configurations of human vision, intellectual or esthetic.

Every such artifact that can occur to us for illustration must have had its origin at some time, recent or remote; it must have been defined in human consciousness, it must have been produced, for the first time. And once having been produced and made public, it can be produced again and again, in the remaking that takes place in consciousness as the configuration recurs to one or another human being. Obviously, it cannot be affirmed without absurdity that the remaking is alone creative and the initial production not. And, on the other hand, it is inadmissible to declare that both kinds of production, the initial production and the repetition, are alike creative, in one and the same sense. For to include under one head every phenomenon of the area to be divided by means of the category is to deprive it of all power of distinction. And therefore it must be the initial production that is crucial in our interest as inquirers about creativity, not the recurrence, which would more properly be called reproduction.

For the purpose of formulating criteria of creativity, it is necessary to understand the products of the mind in themselves and in their first or true production, their origination in the universe: to discern how their production, whether separately or in association with other elements, old or new, differs from their reproduction, their subsequent appearances; to determine whether their production is all of one sort or of more than one sort; and, if it is the latter, to discover exact distinctions between the kinds.

Some illustration is needed to give color and body and concrete security to these abstract considerations. As an example of the mind's artifacts, creative or not, the realizations embodied in the hand saw can serve well enough. Like the ax, the wheel, and the wedge, the saw is of extremely ancient origin. The legend of its invention is available to us, however, as a story delightfully told by Ovid and translated with mastery and charm by Rolfe Humphries:

> During the burial [of Icarus]
> A noisy partridge, from a muddy ditch,
> Looked out, drummed with her wings in loud approval.
> No other bird, those days, was like the partridge,
> Newcomer to the ranks of birds; the story
> Reflects no credit on Daedalus. His sister,
> Ignorant of the fates, had sent her son
> To Daedalus as apprentice, only a youngster,
> Hardly much more than twelve years old, but clever,
> With an inventive turn of mind. For instance,
> Studying a fish's backbone for a model,
> He had notched a row of teeth in a strip of iron,
> Thus making the first saw, and he had bound
> Two arms of iron together with a joint
> To keep them both together and apart,
> One standing still, the other traversing
> In a circle, so men came to have the compass.
> And Daedalus, in envy, hurled the boy
> Headlong from the high temple of Minerva,
> And lied about it, saying he had fallen
> Through accident, but Minerva, kind protectress
> Of all inventive wits, stayed him in air,
> Clothed him with plumage; he still retained his aptness
> In feet and wings, and kept his old name, Perdix,
> But in the new bird-form, Perdix, the partridge,
> Never flies high, nor nests in trees, but flutters
> Close to the ground, and the eggs are laid in hedgerows.
> The bird, it seems, remembers, and is fearful
> Of all high places.[1]

If we should inquire whether this nephew and apprentice of Daedalus, who is usually called Talos, displayed any creative scientific talent, we might use either of the two common proximate criteria I have already cited, productivity and the judgment of experts. As to Talos' productivity there can be no doubt whatever. He was only about twelve years old, yet he had produced the saw and the compass, and he is credited by other authorities with producing also the first potter's wheel. In comparison with him, Edison seems retarded. As for the judgment of his colleagues, it is plain that Daedalus, who was his immediate supervisor and presumably his peer, judged the value of Talos' work to be very great. One can imagine a panel of contemporary judges of scientific creativity being asked among other questions: "Would you push your nephew off a cliff if he had made such and such a discovery or invention -- or would you be content to sneer or shrug?" This travesty of common methods seems to me not wholly unfair.

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[1] From Ovid: Metamorphoses, translated by Rolfe Humphries, Bloomington: Indiana University Press, 1955, p. 189. Copyright, 1955, Indiana University Press. Used by permission of Rolfe Humphries and the Indiana University Press.

There are more rational grounds of procedure. Let us try to reconstruct from our knowledge of the world and of human nature the process which Talos must have followed in production of the first saw, and then try to formulate a description of the essential features of the product. Other story tellers than Ovid report that Talos took as his first model a snake's jaw, but this is less probable, since the teeth of snakes are adapted less for crushing and tearing than for gripping. The scaled edge of such a jaw might have served, possibly as a finer sort of saw. It is not unlikely that Talos used as instruments both jaw and backbone, for some time without modification, and that only when he ran out of good snake jaws and fish spines was he motivated to consider the principles involved and to organize his understanding explicitly and fully. Whatever the specific steps in the process may have been, it seems clear that his imagination set certain elements of thought in meaningful relation to one another, that he associated certain forms and actions of material in an original way -- that is, for the first time in the history of the mind. The instrument itself in its natural form might have been used many times before, by a man or by an ape idly pushing the unconsumable rough-edged remnant of his dinner or someone else's across the soft substance of a melon or other incisable object. Such use, however, does not constitute the production of an artifact of the mind. To achieve that production, a formulation of meaning is required. For, as we have seen, this is what products of the mind really are, in their intrinsic nature.

What occurred in Talos' production of the saw was exactly such a formulation: a structure was brought into being, apart from and independent of actual fishbones and of a different order of reality, a structure embodying realizations of the mind, a pattern composed of ideas or other subjective entities (such as images) in meaningful relation to one another. The second saw turned out in Talos' workshop -- or more probably in that of Daedalus -- had only a physical novelty, it only embodied once again the original formulation of meaning, and upon its completion what was introduced into the world was therefore merely a representation of the old configuration, a reproduction. The saw as an artifact of the mind was produced once, and thereafter reproduced.

It appears to me that we have here the requisite grounds for discriminating very precisely between a creative product and one that is not creative. A creative product is intrinsically a configuration of the mind, a presentation of constellated meaning, which at the time of its appearance in the mind was new in the sense of being unique, without specific precedent. Any such configuration will be new in the totality of its aspect, in the constellation of its component elements of meaning. And it may be new also in one or more of these elements, as in Einstein's theory of relativity the concept of the velocity of light was new, a velocity without archetype or precedent in that it is the greatest velocity possible and remains constant in measure under all circumstances of measurement.[2] Since the definitive aspects of any product of the mind are permanent in it, and are revealed in immediate intellectual or esthetic apprehension of it, they remain perpetually open to our consideration. In examining any product of the mind, we see real and definable entities -- definable, that is, insofar as anything is. And if we can see we should be able to appraise.

In a saw, our immediate example, we have the tremendous penetrating power of pointed prominences, familiar to everyone in the tooth, the sting, the thorn, the spear, the awl, and so on, combined with the accurately dividing function of a blade and the grinding force of a rasp. What happens to be new, original, in the saw, is not the component forms and functions or, more precisely, the concepts of their individual properties. All these would have been familiar to Talos and his contemporaries. What is new is rather their association in the single structure conceived in relation to its use, not their mere aggregation as a group of instruments working together, but their unification in the form and function of one instrument comprising the essentials of several. Talos' act of associating them in a configuration that was new -- if we discount Daedalus' captious insistence on his own priority in this very invention -- is specifically different from all subsequent associations, which merely reproduce the configuration. The initial act, and the initial act only, adds something to the structure of the mind; it brings into being some spiritual increment. All repetitions of the association are no more than the use of that increment.

I propose as the primary criterion of creativity the mind's production of spiritual increment, understood in this sense. If the criterion is sound and practicable, then in estimating creativity we need not be guided by rules of thumb. I believe it can be shown that, in using the method of discrimination I have indicated, it is possible to determine the creativity of a product explicitly and, allowing for the fallibility of all human schemes and procedures, finally too. The distinction, moreover, when accurately made on the basis of historical facts, which are ordinarily available, is absolute, not approximate; and therefore the criterion which establishes it is an ultimate criterion.

In using the criterion, the crucial matter is the product, in itself and in relation to other products of the mind. First we must see, as we have done with the exemplary saw, what artifacts of vision are involved in it, what constituent elements and what constellations of elements. And secondly we must determine which of these, if any, are original -- not original in the sense of statistical rarity, which indicates only a degree of unusualness, but original in the absolute sense of priority in the time of their introduction into the sphere of human thought. The question is not of what is unusual in a product of the mind, but of what is unique in the constitution of the product at the time of its production. This quality of uniqueness, recognizable and definable, is either present in full force or is absent entirely. The products to be dealt with are not more or less suffused with creativity, as an object may be tinged with color in one or another degree of saturation. Either a product of the mind is creative in one respect or another or else it is not creative in any. Thus the proposed criterion is clear and precise in itself and in its application.

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[2] See M. Wertheimer, Productive Thinking, New York: Harper and Brothers, 1945, pp. 179-180.

I take for a first illustration of how the criterion may be applied a highly exemplary piece of purported invention which was cited by Alex F. Osborn, in his book Applied Imagination, as an imaginative solution for which the B. F. Goodrich Company paid an employee $150. The valuable suggestion was that waste pieces of surgical tubing be sliced into salable rubber bands. If we use the word creative as a vaguely commendatory epithet, as the word splendid is often misused in recommending commercial opportunity, the proposal to convert tubing into bands will readily be called creative. But, if we consider the suggestion at all closely, we shall see that it involves only reproduction of an old insight, the same that enables any small boy to make rubber bands out of discarded inner tubes.

The product in question is a familiar example of the fruitful conversion of one form into another by a process of fragmentation. A little thinking was required to reach the employee's solution, and though a little thinking is often rare enough to be rewardable, neither the rarity nor the reward is any ground for calling it creative. If this bit of thinking must be called creative, then any intelligent association of ideas that is not inevitable routine in the mind must be called so. And if it must, then here we have the lowest level of creativity. Judged by this criterion, recourse to the constellations for guidance in lack of a compass would have to be called creative, although it is an immemorial expedient; controlling the flapping screen door with a strip of inner tube instead of a spring would have to be called creative. But I believe we must consent to call this sort of thing resourceful.

Resourcefulness is a very fine thing, and yet it is not the same thing as creativity. Drawing on available materials and guiding his behavior by accumulated knowledge, a man who deals with the occasions of life actively, flexibly, and in ways that, unusual or not, truly meet the demands of reality will be acting resourcefully. Only if his ways of dealing with these occasions are in any respect original, in the absolute sense I have indicated earlier in this discussion, will he be acting creatively.

An example of truly original production is to be seen in Rorschach's invention of his inkblot test. Since he followed many precedents, it is necessary to examine the test in some detail in order to determine exactly the nature of his contribution and the degree of his creativity.

The inkblots of the test, accidental shapes made as the ink has chanced to fall and spread, are perhaps its most obvious feature. Each of these conformations is divergent enough from every recognizable object that it constitutes an image without specific identity. And therefore, when a subject is set to interpret one of these blots, to assign to it some specific identity, it will admit apperception of such specific form or forms as the subject's inmost propensity may determine while he views it.

Such subjective determination of the indeterminate aspects of images was well known long before Rorschach's time. There is a good example of it in Polonius' and Hamlet's conversation about clouds:

Ham. Do you see yonder cloud that's almost in shape of a camel?

Pol. By the mass, and 'tis like a camel, indeed.

Ham. Methinks it is like a weasel.

Pol. It is backed like a weasel.

Ham. Or like a whale?

Pol. Very like a whale.

In this brief exchange, of more complex meaning than we need to consider, Shakespeare has represented something like a passage in a psychological test. On the basis of data afforded by Hamlet's responses to what can be called anachronistically the Rorschach blot of a cloud, Polonius seems to have strengthened his opinion that the man was mad. Probably he thought the subject's three interpretations of the form unrealistic and flightly, further evidence of Hamlet's disorientation and instability.

The principle of testing involved here, evidently an old one, is the same as in Rorschach's test. And, as we have seen, the most striking part of the apparatus of the test is basically the same. Rorschach, moreover, was not even the first to use inkblots in psychological testing. Yet the earlier experiments with inkblots had been confined by the assumption that the test was essentially a means of revealing imagination. In producing his test, Rorschach added something to all this, and his doing so was an act of creation.

His achievement lay in his perception and development of a new possibility in the recognized fact that we reveal ourselves through interpreting the forms of clouds or inkblots, or stains in wallpaper and so on, taking them as expressions rather than naming them for what they really are, bodies of mist or the marks of liquid staining pieces of paper. Rorschach alone saw that in using the old known process of expressive interpretation, controlling the stimuli and appraising the responses in various ways to the end of discovering the whole range of eidopoeic or form-making procedures, powers, and tendencies of the subject's mind, he could obtain a systematic revelation of the structure of any personality. The insight thus introduced into the sphere of human thought and displayed and verified in its full development was new.

I do not know that anyone has extended the application of Rorschach's original insight, in producing another test making the same use of accidental, nonspecific structures, but using a radically different kind. For the sake of an illustration, I will do so, although in hypothesis only and while assuming that someone else has not preceded me in the specific development I will present. It might be described as a Rorschach test for the blind and be thought of as a solution of the problem of inventing such a test. Instead of inkblots, the standardized items for perception and apperception would be pebbles or stones of various shapes and sizes. The pebbles could be manufactured from suitable substances to resemble the various textures of stone, and their weight could be determined by making some of them hollow and some solid and by loading still others with lead. The weight of these objects, because of its erratic occurrence in relation to texture, size, and shape, might be found to have something like the function of color in the Rorschach test. One might moisten the stones or otherwise startle the subject receiving them into his hands, and thus achieve further elaboration of the test. Experiment would be called for, and the whole potential value -- or worthlessness -- of the test would have to be demonstrated. It might permit us to reshuffle the Rorschach cards and to deal a hand to the blind. And for the sighted it might be discovered to have significant new uses.

Its value for the present occasion is as an example of a production of the mind achieved through a fresh application of old insight, through realizing a constellation of meanings which reproduce in their general structure an old configuration but in their particular adaptation transcend it. Much so-called invention and creativity -- including a great deal of problem-solving -- is no more than this sort of fresh application of some configuration earlier produced, an extension in the use of its basic design, a representation of it in a new guise, often with the advantage of fresh aspect and fresh practical possibilities. The value of these added advantages may be very slight or nothing at all. But it also may be enormous, and the operation that produced them may be said to have created them in the sense that it brought them into being. The glow of that accrual and the dazzle of semantic complexities can combine to confuse and deceive us unless we have recourse to an idea of creativity rationally conceived and explicitly defined. Under correction of the criterion I have proposed, it would have to be conceded that whatever may be brought into being in the way described, through a fresh realization of old insight in new particulars, must be in part credited to the instrumentality of the old insight. One who merely puts the old to some novel use can claim to have produced only a small part of the whole complex of significance involved; he can claim only the specific new application. He should not be credited with more; the value of his performance should not be exaggerated.

But neither should it be underestimated. The difficulty of making any such extension in the use of old configurations of thought is evident in the invention of printing. The history of the invention of printing in Europe is obscure. But it appears that the printing of books was a particular adaptation of the general idea embodied first in the printing of pictures, which preceded the printing of books by some years. Evidently the essential concept developed first in a restricted form, as the idea of making multiple impressions of the images of objects, and its general implications were for some time ignored. The extension of the idea to include the images of concepts, the words reproduced in printing, seems to have awaited a fresh thought, involving the reproduction of the general idea in different particulars than those which embodied the initial insight. Apparently this later product of the mind, far from springing into being as an inevitable concomitant of the earlier insight, had to be originated too. It is clear, then, that to originate a configuration of the mind is not to produce in the mind all of its possible applications and variations. These are further developments which have to be brought into being in contravention of the mind's somewhat rigid and lethargic submission to existing order.

I have argued that in essence a creative product is a spiritual increment, more or less extensive, an addition to the intellectual and aesthetic design in terms of which the psyche organizes its energies in the intricate process of being and understanding. Creative production is at once action and revelation, new movement of the subjective energies and emergence of new meaning amid the universe of meanings, the whole scheme of vision that any society sustains.

Since creative work is essentially the movement of the spirit overpassing old limits, it is fundamentally understandable and appraisable only as spiritual advance. Apart from that action, its gifts are as inscrutable as the gifts of nature. Though practical value is relevant in judging the consequences of creative work, such value is contingent rather than essential in the work itself. And therefore the familiar difficulty of estimating creative power in terms of practical consequences of its productions need not trouble us in defining fundamental criteria. However relevant to some purposes such estimates may be, they are irrelevant to the estimate of creative ability in itself. That ability is shown only in origination of significant order in the subjective sphere.

As there are two distinctly different modes of originating such order, one mode far more difficult than the other -- and less common, it is reasonable to say that there are two levels of creativity, one higher and one lower, one primary and one secondary, one major and one minor. Creative action of the lower, secondary sort gives further development to an established body of meaning through initiating some advance in its use, as in the example I have given of the extension of the printing of pictures to include the printing of the images of verbal signs. Through relating known concepts or other elements in accordance with known principles by which they have never been ordered before, the secondary kind of creation extends the range of application of some existing significance, without altering it intrinsically. Or, in other words, it initiates wider use of some formulation of meaning already developed within a universe of meaning. And thus it brings to some area that had been dark a familiar light.

Creative action of the higher, primary sort alters the universe of meaning itself, by introducing into it some new element of meaning or some new order of significance, or more commonly both. The new insight or body of insights thus contributed to the universe of meaning may augment the whole without displacing anything fundamental in it. The quantum theory was such an addition, a new constellation against virtually unconstellated darkness. Or the new insight may supplant all or part of some strongly established area of vision. Einstein's relativity theory, for example, reconstellated a large area of understanding. Whatever its relation to the established universe of meaning, the higher sort of creative action invariably brings into the mind an unfamiliar light.

The mind in its major creative action assumes responsibility for making and remaking the universe of meaning sustained by the culture in which it moves. The mind in its minor creative action takes responsibility for something less, for extending the application of known order within the established universe of meaning, the general contours of which are a limit it does not alter or transcend. Thus in the minor mode of creative action, the mind moves in dependence upon existing order, but moves more expansively than uncreative minds, or than the mind in its uncreative action. In the major mode of creative action the mind, transcending existing order, moves in relation to all that has not yet been matched with significance, the matchless plenitude of all things.

It is improbable that any human being is so constituted that creative action of some sort and in some degree has never been within his capacity. Yet not many show much ability to act creatively in any distinctly recognizable degree. Apparently, relatively few men are competent in both modes of creation, more are competent only in the minor or secondary mode, and many are competent in neither mode. We can discriminate among them by examining the products of their minds.

Q--Assuming, it is true, as I take it to be, that you are not acquainted with previous attempts to make three-dimensional Rorschachs, isn't that your invention here? Doesn't it constitute a spiritual increment, in your terms?

S--Yes, I had represented it as that, as an example of an ignorant man's creative production of something he believed to be new but that probably had been produced before, and much better, by other people. Actually my creativity in devising the test is questionable because, although I never heard directly of any such test, many intimations of prior inventions of virtually the same thing may have come to me through indirections. Nevertheless, I think the production of the test serves hypothetically as an illustration of the second level of creativity.

Q--Isn't priority in production a question of what one is aware of when he makes any invention? That is, if you are not aware of previous inventions of this sort, and somebody else is not, and both invent the same thing, make a simultaneous invention, or one invention comes maybe much later in time but in ignorance of what others have done of the same nature, isn't it equally a spiritual increment?

S--It is a spiritual increment of a sort, it is that for the individual mind which expanded its own insight. But it is not so for the group which has already received that increment. If the individual is ignorant of what is already known, he may only be wasting his effort, and the resources of society, in doing something that has been done before.

C--The point is that in the creative individual there will occur in his own experience, perhaps only in relation to himself, some totally new meaning which (if you want to speak in terms of spiritual increments in the universe) is a spiritual increment in the individual life. That would be a criterion of creativity in the individual.

C--I'd like to interject one thing. It seems to me that the worst enemy of creativity that you can find almost anywhere is fitting a halo to it. That is, I was talking to a number of young fellows yesterday who were the kind of people who get the highest grades in the university. A number of them were deciding that they couldn't -- shouldn't -- go into science, which happened to be the thing that was being talked about then, because they probably weren't original. They could get the best grades of anygody, but they had some exalted idea of how wonderful the creative act is and they believed there is something quite special about it. It seems to me that the big universities tend to overawe the students and in the end turn out many fewer people than the less gifted people who are in the small schools. I'm thinking of a lot of the schools where there are teachers with less ability but who live with the students and lead them along and keep them from thinking that creativity is something quite wonderful. As far as I'm able to tell, there isn't a thing so stultifying as to exalt it. If you take writers, if you take Shakespeare, he probably didn't even set out to be creative. He just did create, along with everything else. All good experiments are done in a day's work. You don't set out to do creative things; you set out simply to do something that you're interested in, and if you ever are creative it's a by-product. To be scared about it is to make sure that you'll never do anything.

S--In this overconscious age, we're more likely to be frightened than Shakespeare was. But Shakespeare's contemporary Ben Jonson did cite some of the ancients on the subject of creativity. So at least there was some awareness of it. But I would certainly agree with you in your general statement. I would suggest that if these young men are still depressed you might send them to my two-unit course in the creative process, in which I try to demonstrate that creativity is not the possession of the few, and can be cultivated.

C--I would like to suggest that maybe we need more than one definition of creativity, and that this is one of the definitions we need, and it depends upon what we are interested in, or the purpose for which we're using it. Perhaps there's a better term, but this is a social definition of creativity, or a spiritual definition in terms of increment to knowledge. And if our purpose for the moment is to understand real additions to knowledge or to predict who will make such additions to knowledge, then it seems to me this is a useful definition. On the other hand, if our focus is on understanding the behavior of the creative individual, then I would want to define -- as I think you were implying -- I would want to define the creativity of an individual in terms of his making, as I understood you to be saying, an addition to his universe, in your terminology. I don't know whether Leibniz had intimations, when he invented the calculus, of the fact somebody else was doing it. Suppose we discovered, for example, that in another culture -- the Chinese culture -- many of these things had been done before.

S--We have had this sort of experience.

C--We do this frequently. I think, from the point of view of understanding the creativity of the people who did it in our culture, this doesn't lessen their creativity. I think this is a matter of degree, down to the eight year old boy who, for the first time for himself, may create something that has been created hundreds of times before. In terms of the second definition, this is creative. I would simply say that for the purpose of understanding the psychological process, the second definition -- the second approach -- is often useful. For another purpose, what I call the "social addition to knowledge definition" is equally useful.

S--I think my definition comprises the one that you recommended just now.

Q--Both?

S--Both. My hypothesis is that an invention or discovery is truly creative insofar as its coming into being is really production of insight, rather than reproduction or copying of insight in any degree whatever. It can be truly creative production even if it duplicates a preceding discovery or invention. But within any culture the real independence of creative acts that duplicate one another is hard to make sure of.

Real independence is perfectly assured, no doubt, when the duplication occurs in different cultures completely isolated from one another. Then, we might say, the separate cultures within which the duplications occur are like island universes. Each is a separate system of insights unaffected by the development that has occurred in the other system.

C--But take Leibniz and Newton. Was Leibniz's universe different from that of Newton when they both, insofar as we know, invented the calculus? And this is a question of scientific history.

S--This is a crucial question, whereas the other, concerning separate cultures, such as the Tahitian and the Chinese, I think disposes of itself. Leibniz and Newton, who shared the insight current in seventeenth century Europe, simultaneously explored the same frontier of the unknown. If these two people were not in touch with each other in any way during their explorations leading to the discovery of the calculus, then the probability is that both acted in real independence and that the discovery was for each one equally an invention.

But if one of two purported creators derives his supposedly new insight in any degree from the other, he must yield credit for its discovery or invention to the other. The priority in time is not discriminative, unless the priority in time allows for transference of the new insight, even of some suggestion of it, even of the slightest facilitating hint, to incite or direct the mind which comes second in time.

C--There is a distinction here in terms of the point of view of the observer. One kind of observer is the omniscient observer who sees all of the universe in all its history and says, here is the initial appearance of this new constellation, this addition to meaning in science. And the other is the observer who only has his own experience to go on; and when within him there occurs this new configuration you would say that it's equally a creative act in the highest sense. Would you not?

S--I'd agree but for the qualification which I made just now, that the man who invents something already invented can be said to have created it only if he has received no helping hint, from any source, of the purportedly new configuration which he produces. Such hints or intimations may reach us in devious ways. Our whole culture is unitary, and there are extremely subtle transferences of suggestions from one mind to another. Take, for example, the influence of Samuel Greenberg on the poetry of Hart Crane, and, through Crane, upon others. Samuel Greenberg died quite young. He had never been published. Hart Crane saw some of his manuscripts and incorporated some elements of Greenberg's style -- his way of looking at things, even -- into his poetry, and he owes a certain degree of what seems his originality to Greenberg. That is an example of derivation by direct influence. Now others, without ever reading Greenberg or Crane, might embody in their work the same patterns of vision or the same freedoms in association of materials that Greenberg originated and embodied in his, and they might be thought to have originated them in their turn. But if it could be demonstrated that they had read people who had been influenced by Hart Crane, even at second or third remove, then we would have to suspect that the duplication arose through diffusion of insight, rather than through successive independent creations. If the duplicators were found to be creative, it would have to be upon other grounds, their production of new design, not their use of old design, which they would only be reproducing.

Q--But don't you think that occurs in all instances in the creative act?

S--I think this sort of obscure diffusion of insight is a universal phenomenon. Derivation of some components of new work is natural and valuable and universal. All I mean to insist upon is that it should be discriminated from invention, and that derived elements of purportedly creative work should be distinguished from invented elements or aspects of the work.

Q--Right along this line: You have this broad creativity, and it seems as though it must emerge in the form of an idea--that is, true creativity. You've talked about where secondary creativity comes from. What do you think is the origin of an original idea?

S--Of the primary kind. It seems to me that this truly original kind of insight comes in response to a need. We begin by sensing the insufficiency, as vision, either of the whole of what I have called the universe of meaning, or of some part of that universe of meaning. The creator's need then is to configurate in a more adequate way all the reality which he feels to be inadequately represented or ordered in that universe, that scheme of meanings. What the major creator feels for primarily is not a system of meanings that calls for elaboration or correction in accordance with some known order; it is the whole plenitude of unconfigurated fact, in relation to an order as yet undiscovered. I tried to hint at this in the penultimate paragraph of my paper.

C--You are working on unconscious resistance, because this makes all scientists secondary creators.

C--I don't understand your discarding of the possibility of what you call any hint. Of course you get leads from everywhere. You don't live in a vacuum. It's impossible. You just up and create in your mind without reacting to what other people have done. Everything is built upon what has already been done, to some extent. I don't think that this in any way derogates from the creative process of the individual who uses something from this person, and something from that person, and something here, and puts them all together in a new way. The fact that there may have been foreshadowing, to some extent, is necessary and does not make the other man any less creative. I can't understand what you mean by that.

S--I don't think use of existing resources derogates in the least from anyone's creativity. But any derivation from available cultural riches decreases the amount of newness that is involved. If everything is derived, all the elements and the way they are put together, then there is nothing new and there is no creation. Therefore I discriminate from all those things which the scientist derives, directly in explicit ways or indirectly by means of hints or intimations, all those other things which are absolutely new, such as Einstein's basic conception of the velocity of light as a velocity constant in measure under all circumstances of measurement. I would ask Professor Eyring if this is an adequate example.

C--I think that is an interesting example, and it seems to me that on your basis you'd have to put Einstein second rate, because surely the Fitzgerald - Lorentz contraction was very well known; the equations were written down and were well understood in their work; on that basis all the special theory of relativity was done before. He took it, and understood it, and thought of it, and made hard the idea that you pointed out, which seems to be the essential idea, that the velocity of light is invariant. But surely Lorentz had gone a long way and Poincaré also had gone a very long way in the specialty of relativity. So that, in that case, I think you could make quite a case for Einstein as being second rate on the definition that he drew very much of it from things that went before. Whereas, he was really very first rate, about that there's no question.

S--The idea of creative work I have been supporting is consistent with Einstein's acceptance as first rate. My hypothesis does not require that in the highest form of creativity nothing be drawn from the past. Any mind draws more or less from the shared human vision. But I have maintained that the mind creates only in adding new elements to that vision or in giving to old or new elements a fresh configuration. Whatever the degree of Einstein's creativity, I believe it must be estimated upon those terms.

C--I think it was first rate, I don't think there is any question about that, but it surely was very much foreshadowed in things that went before. That's all I'm saying. I don't know anybody that does it better than Einstein, but Poincaré and Lorentz and Fitzgerald had really done the thing, and the mathematics are still the same, the same equations are written down, and he simply saw it much more deeply, and said it much better. It seems to me you've picked out very well the invariance of the velocity of light as something you want to tie to.

S--I am reluctant to concede that Einstein's creative preëminence lay solely in his scope of thought rather than in his contribution of new insight, his enlargement of human vision. But that must have been the nature of his preëminence if it is really true, as some of you seem to say, that Einstein only assembled other men's ideas, relating them to one another in an old order, which though complicated was not new either in any of its elements, with the doubtful exception of one, or in the pattern of its complication. I would like to inquire more precisely as to exactly how one might define the precedent that Einstein followed.

SCIENTIFIC CREATIVITY

Henry Eyring
University of Utah

S--It seems to me that in choosing the above topic, I have tried to take hold of a very difficult subject with a very primitive means. Some of the material that I will cover was presented earlier this year at the Michigan State symposium on creativity.[1]

Much of what I know about teaching was learned when I tried to break young horses as I grew up on a cattle ranch in Mexico. A very good way to make a horse balky is to try at the very beginning to make him pull more than he thinks he can. My picture of the University of Utah and Princeton and the other places that I have been is that many of the very able instructors are expert in the business of getting status for themselves, of putting a halo around creativity and other high quality productivity, and unfortunately, in that way, of teaching the young people so that they do not know how to pull.

Another notion that seems to me to be true is that actually, the best way to make outstanding creative persons is to make good hacks -- I mean, people who just keep working -- because it seems to me that the creative thing always comes out of, along with, and incidental to, a lot of things that are sometimes not even good. I am thinking of people that you might think of -- Shakespeare and Einstein, for example -- who wrote in many, many fields and did different degrees of good work (always quite good actually, because of ability), but certainly they were very widely productive.

One other thing that I want to say is that a great deal is often made of the idea of parity and I think we all know what it is, but I will take a few minutes to speak about it. Physicists, particularly since they have been working on quantum mechanics, have used an idea that for an atom you could just turn it wrong side out. In other words, if you were to use a sphere, you could take any one point on one side and transform it right through as far on the other side of the center, called an inversion, and do that with every point, but you would not have changed the properties of the atom. They loved that idea so much that they enshrined it. One of the consequences is the notion that the south pole must be exactly like the north pole. Later they did do the experiments of actually putting cobalt atoms in a magnetic field. When they found that the cobalt atom shoots its electron out of the south pole rather than the north pole, they were literally overwhelmed. They should not have been overwhelmed, because they had no basis to begin with really, for assuming that the south pole was like the north pole -- that inversion would not change the properties -- except that it is the simplest thing to assume, and so they assumed it. This new idea made a terrible splash, but I do not think I want to take the limited time to try to analyze what all this means by way of creativity.

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[1] This paper has been adapted from an address on "Scientific Creativity" presented at the Symposia on Creativity, Michigan State University, 1957. Printed in advance of publication by permission of the editor and publishers. From Anderson, Harold H., Editor, Creativity in Principle and Process. New York: Harper and Brothers. Scheduled for publication, 1959."

The notion that everything living is optically active is exactly the same idea applied to molecules. Chemists have had to learn to live with the idea that you do not have a center of symmetry -- you cannot invert things. Whether things had that kind of symmetry or not is something that people had thoroughly thought of and at first they were simply guessing whether nature was one way or the other, and they nearly always guessed the simplest thing. Of course, it is easier to guess that there is not any difference between the two ends because then you do not have to think about it any more. And so it is the economy of thought that certainly guides people, and when you have found that you have to be less parsimonious, then you have made one kind of advance.

Let us now proceed with a more formal treatment of scientific creativity. Each person is born into an environment with a language and culture that provides a more or less complete world view. He usually correctly assumes that his first conflicts with the notions he has learned will be resolved when he understands the accepted views better. Sooner or later, however, he usually comes up against glaring inconsistencies which bring his conceptual world into serious question. The necessary reconstruction, if he is willing to attempt it, is the beginning of a creative process limited only by the expertness of the innovator and the time devoted to it. This intellectual construction of a world picture is an extremely important aspect of scientific creativity.

Operational character of science

Beginning chemistry sparked one of these earliest re-evaluations for me. Professor Tartarian, an excellent teacher at the University of Arizona, nevertheless, presented the chemistry of copper in a didactic fashion with little regard for the experimental evidence for his revelations. It was a matter of real satisfaction when I finally realized that copper is simply a name useful in describing a certain collection of experiments. I also realized that most any other name would have done as well and that the experiments reported in the literature might be, or might not be, reproducible. Thus, science became operational -- something to be tried over again if questions remained.

Recurrence and the idea of variables

As soon as one gets to the point of making systematic observations, the question arises as to what observations are worth recording. Clearly any actual event is extremely complicated and if described in sufficient detail is unique in the history of the world and will never recur. Such a detailed view of things, being non-recurring, can help us to understand neither the future nor the past. Only those aspects of a situation which recur can give us useful insight. Thus, in science, whether or not we say it, we always mean that in comparing two events certain special aspects of the situation are changed while everything else that matters is kept the same. Thus we have forced upon our attention the idea of variables which influence events.

Time as a variable

Very early in this process we are obliged to give a meaning to time. The conception of elapsed time resolves itself into the recognition of change. Time is measured by counting the number of recurrences of some cyclical process. The usefulness of the conception of the uniform flow of time becomes apparent as soon as it is clear that many seemingly independent cycles have durations which are in fixed proportions to each other. This correlation between the duration of isolated events is simplest to understand when we consider identical systems. Thus either of two ammonia molecules invert 2.39×10^{10} times per second, as can be shown by microwaves, because they are identical and there is no reason for them to behave differently. Again we use the principle that turned out so badly with the atom. This orderly periodicity of an almost endless variety of events is a verifiable and exciting fact of nature. We might, with Newton, think of a uniform flow of absolute time in which all these events are taking place, or we might think that there is a correlation between durations, because one periodicity is, in fact, determined by all the others. The special theory of relativity forces the latter conclusion since relative velocity of two systems shifts one frequency with respect to the other. That is, you have two moving bodies and you have got to have your clock change, and your clock is simply some periodicity. As always, however, this result starts from a conscious choice. One has elected to treat the velocity of light as the same in the resting and in the moving system, and let the moving clocks and moving meter sticks change their values in the appropriate way for this to happen. You do not have to. You can do something different, but you can get things systematic and that is what Einstein found out -- that he could do it the systematic way. Mathematically you could turn it around and do a lot of complicated things and not necessarily have uniform velocity for time in all systems moving with respect to each other.

Positional coordinates

The Foucault pendulum with its bob at the end of a long wire, vibrates on a nearly frictionless support and oscillates in its fixed plane in space as the earth turns under it. We are all familiar with the fact that if we hang anything like a ball from a very high point, as Foucault did in the cathedral, let the ball move, and then watch the day go by, that the ball seems to be turning in a different direction. That is certainly a very difficult question philosophically. With the disappearance of the ether and Newton's absolute space, cosmologists are faced with the problem as to what determines the inertial coordinates for the pendulum. Again one adopts the view, which is consistent with relativity, that the coordinate system for one body is determined by the rest of the bodies in space. It is interesting that the laws of Newtonian mechanics, relativity, and quantum and statistical mechanics, together with such derived properties as energy and momentum, are relations between these space and time coordinates.

Some factors in discovery

Newton could arrive at his law that in the absence of such things as viscous resistance the mass of a body times its rate of change in velocity is equal to the force acting on it, only by ignoring Aristotle's incorrect notion that force is always required to keep a body moving at a constant velocity. Newton's task was made more difficult because under certain circumstances Aristotle's law is actually true. For example, force is required to propel a body at constant velocity through a viscous medium. This is illustrative of the enormous complexity of natural phenomena.

Creativity is rarely a single flash of intuition, but usually requires sustained analysis of a great many observations to separate out the significant factors from the adventitious. A keen observer once said of Einstein that part of his genius was his inability to understand the obvious. Rejection of superficial explanations of one's own as well as of others is prerequisite to understanding. To reach a correct solution efficiently also requires unconcern for all else except the truth. Any practice in science to bolster a faulty hypothesis rather than to test it objectively is often worse than useless.

Some characteristics of the effective innovator

Undoubtedly the prospective scientist should arrange to be born with the right genes. Anyone who has examined the variations to be found among individuals with ostensibly equivalent training cannot escape this conclusion. However, even the gifted individual requires a stimulating environment, including freedom from distractions which deflect attention from the question at issue and freedom from an authoritarian society which prevents unbiased enquiry. He profits likewise from congenial surroundings and stimulating company. He should preferably be completely at peace with the world except for the violent conflicts characterizing the problem engaging his attention. He needs to be independent of all types of vicious circles[2] which deflect attention from the problem at hand. The lone wolf has solved many problems, but an increasing number of scientific enterprises are becoming highly cooperative and require social integration. On team projects no degree of talent can fully compensate for an impossible personality inside the large scientific laboratories which are doing an ever increasing proportion of the creative work of the world.

The creative process

No serious investigator need ever be without a suitable problem appropriate to his talents. Every field is either (a) well understood in which case a book can be written about it, or (b) it consists of uncorrelated experimental and theoretical material suitable for a review article, or (c) certain experiments are in need of theoretical explanation, or (d) critical experiments are needed to settle knotty questions. Only lack of interest, or of time, or an overwhelming ineptitude deters the prospective investigator from the creative process. Usually the excuses given for failure betray an amazing inventive talent and a vivid imagination. Such brilliant efforts are worthy of better causes. On the other hand, a genuine tragedy is presented by the brilliant mind with a critical faculty so far outrunning creative imagination that the unhappy possessor is forever condemned to bitter sterility. How often such cases are really incurable and how often cooperation, encouragement, and the elimination of the effects of hypercritical companions can work a cure is of the greatest importance.

Creativity is manifested at many levels and takes a variety of forms. An exciting variety is the recognition of analogies. A fruitful new field was born when Van't Hoff, long ago, recognized that large molecules confined to one side of a membrane by their inability to permeate it nevertheless sucked the solvent through from the other side because of the tendency of the large molecules to expand the space available to them, just as a confined gas would do. You've got the membrane; you've got sugar in the solution; you've got water on the other side and these molecules hit against the surface of the water, and they just pull the water in because the thing wants to expand just like you would know if you tried to hold the gas in. Van't Hoff saw that picture very clearly. As a result, the laws of gases were taken over intact and applied to interpret osmotic pressure. The faculty for recognizing such an analogy resembles the ability to recognize a recurrent musical theme running, with variations, through a composition. After the variations are stripped away the recurring pattern is recognized for what it is.

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[2] See Harold H. Anderson and Gladys L. Anderson, The Manual of Child Psychology, 2nd Edition, John Wiley & Sons, Inc., New York, Copyright, 1946, 1954.

Still another such example is the recognition of the thermodynamic equivalence of a molecular sized hole in a liquid to a molecule in the gas phase. The picture is that a solid is a very well organized substance where the molecules are exactly in position. What happens when the thing becomes a liquid? It becomes random, but why? Because molecular sized holes go into places, and as soon as a hole goes in, then a molecule can jump into that position and another one can jump into the other one. When one follows that kind of a notion a little bit farther, one realizes that he has a beautiful duality -- that is, he has a liquid, and up above it, he has a gas. In following thermodynamics a little bit farther, one finds that the molecule, when it goes into the gas, breaks the bonds that hold it to its neighbor. (That's a horrible thing to do -- molecules shouldn't do that, but they do break their bonds.) But the compensation is to be able to wiggle freely and to increase their entropy. It turns out that by a slight amount of arithmetic you can find that to take a molecule and move it in the gas phase, you break just exactly the same amount of bonds as if you took a hole from upstairs in the gas and put it down in the liquid. The hole can have just as much fun in the liquid as the molecule can have in the gas phase because it runs with the same velocity the way a hole moves with a molecule jumping the other way, and so it moves with the velocity of the molecule because the molecule jumps one way and the hole jumps the other. By taking this picture, one has the notion that holes have just as much fun in liquid as molecules do upstairs in gas. From these considerations follows the thermodynamic necessity that there are just exactly as many molecules upstairs as there are holes in the liquid. One thereby comes to a very beautiful explanation of the generalization of Cailletet and Mathias in the so-called law of rectilinear diameters, namely, that if you add the densities of the liquid and the gas, they stay constant. Then you have to bolster the explanation a little because you have found out that holes can break in two and you have to account for them. If they had all stayed the same size, you would have an exact law, but you fix it always, and that is part of scientific tinkering.

Idea-generating concepts and intuition

From time to time exciting new principles are required to explain experimental facts. Not infrequently the concepts have been guessed at for ages, but until the proof of their correctness is available, such guesses can only be suggested and are often ignored. A famous example is the insistence of Democritus and Lucretius that matter is composed of discrete particles. The peculiar shapes of the particles were supposed to account for differences in properties of the different substances. More than a millenium later, evidence had finally accumulated that elements combined in definite proportions and that when the same elements formed a second compound, the ratios of the amounts of the elements were in simple multiples of those found in the first compound. This idea of atoms was just what you needed to explain the fact that you could write down formulas for compounds and that the elements were in fixed proportions to each other. Dalton marshalled the evidence and was able to show convincingly that this evidence required the conception that the elements are formed of discrete particles -- atoms -- which are combined in various proportions to form a variety of compounds. Which one was the discovery, the intelligent guess of the principle or its proof? Here the answer is unmistakable. The inspired guess bore no fruit through the centuries, while the principle, once proved, was immediately fruitful. A characteristic feature of a good proof is that it can be repeated and understood. People who have been right in a scientific matter and yet have been generally ignored by other competent scientists usually lacked sufficient proof.

It is interesting to consider what qualifications make for scientific intuition. The familiar story of the lost race horse is instructive. The lost horse was sought for all day by the entire town, unsuccessfully. On the second day the village fool went out and in an hour had returned with the horse. In response to enquiry as to his procedure, he explained that the first day he sat and thought what he would do were he a horse. On the second day he went to the point where he himself would have gone. The horse was there. We can think about the atoms, of course, in a similar way.

Another example of an idea-generating concept may be instructive. This is taken as a personal example, since I understand it better than some others. The activated complex in the theory of chemical reaction is an example of such an idea-generating concept. The atoms in molecules are held together by chemical forces. These bonds consist of two electrons shuttling back and forth between a pair of atoms much as two baseballs might be kept in the air by passing them between two players. Mesons hold nucleons together in the nucleus in an analogous manner. This shuttling back and forth of the electrons lowers the electronic kinetic energy with no corresponding rise in potential energy. The lowering of kinetic energy arises because the longer electronic path constitutes an increase in wave length and hence a decrease in frequency, and therefore of energy. A chemical reaction between two pairs of bonded atoms occurs when they crash into each other with such great force as to forget to whom they belong, subsequently separating with new partners. I haven't time to go into the sociology, but it is true. Concurrently, the electrons alter their path to circulate about the new partners like children in a family. The crowding together of the two pairs of bonded atoms in the activated complex results in one electron pair being pushed into a higher energy state. This high energy electron pair, as a result of this promotion in status, avoids running into the other electron pair which completely preempts the lowest state of the four-atom system. This general result that one pair of electrons having opposite spin fills up a state is known as the Pauli principle.

The metastable, intermediate state between reactants and products, as was indicated, is called the activated complex. A clear visual picture of the activated complex requires an understanding of the potential energy surface in configuration space. You have to know how much the energy of a system depends on the relative position of the particles -- of the atoms. A sufficient number of the interatomic distances of the complex to fix its configuration are plotted. These distances are taken normal to each other and to the energy coordinates of the system in hyperspace. If you take atoms, for every distance there is an energy. If you think of that energy as you think of a contour map, then you can think what happens for any chemical reaction -- such as taking two atoms of this kind, which go together and change partners, and with every distance corresponding to an energy, you get a landscape. The chemistry is the problem of studying how you move from one valley (a region of low energy) through a pass over into another region of low energy. And the activated complex is this system at the top of the pass. The machinery already exists that was developed before this type of concept came along. As soon as you got the conception that the top of this thing was to be thought of and treated with the same machinery (mathematical machinery) as you treated molecules down in the valleys -- that you could do exactly the same thing with these at the passes -- then you had a complete theory of reaction rates which had been puzzling people for a very long time.

The activated complex is much like an ordinary molecule, except for the internal translational degree of freedom corresponding to the passage over the potential barrier in configuration space. Transit across the barriers is so fast that the activated complex (this thing at the top of the pass) survives only a kinetic jiffy (10^{-13} seconds at ordinary temperatures, only one ten million millionth of a second). It is nice to have a theory like that because no one can look at it, you see, it happens so fast. As a result, its properties must be deduced from quantum mechanics or from reaction rate data. Its fleeting existence precludes direct measurement. With this conception of the activated complex, reaction kinetics is finally systematized to the same extent that equilibrium theory is systematized by thermodynamics.

The velocity of any reaction at unit concentration of reactants takes the mathematical form: $k' = \varkappa \frac{kT}{h} K^{\neq}$, where $K^{\neq}$, like any equilibrium constant, fixes the concentration of activated complexes, $\frac{kT}{h}$ gives their rate of decay, and $\varkappa$ is the fraction decomposing which do not immediately reconstitute themselves. This rather technical theory is outlined here because it is the point of departure for understanding all chemical changes and is also an example of creativity falling within my experiences.

It is perhaps instructive and interesting to detail the genesis of the activated complex concept as I recall it from my personal experiences. Fritz London in 1928 suggested an approximate way of constructing potential surfaces in configuration space using quantum mechanics. In the spring of 1930, following a modified procedure, I laboriously constructed such a surface for the reaction of a hydrogen atom with a hydrogen molecule, in collaboration with Professor Polanyi in Berlin. It occurred to me that if the potential surface for three atoms colliding along a line were constructed to scale, a ball rolled on his model surface would mimic the behavior of the three atom system. The next time I met with Professor Polanyi at his home in Zehlendorff, Dr. Wigner was there, and I spoke of this concept. Dr. Wigner said, "That is a beautiful idea." He proceeded to sharpen this concept in an addendum to a paper by Polanyi and me, and in 1933, with Pelzer, he extended his ideas into a statistical mechanical calculation on the rate of the hydrogen reaction using the potential surface

Polanyi and I had calculated. In 1935, after much labor, I gave the generalized version of reaction rates, introducing the idea that the activated complex is like an ordinary molecule, except for a fourth translational degree of freedom. Polanyi and Evans followed this with a lucid treatment emphasizing pressure effects.

Several points are interesting in this bit of history. First, had there been some easy way to calculate potential energy surfaces, I would probably not have labored over them to the point where the concept of a ball rolling through the saddle point was hammered into my consciousness. Secondly, although the potential surfaces one can construct are very rough and the purist suffers when he uses them, still they provided the bridge one must use to cross over into the field of general reaction rate theory. When quantum mechanical methods yield better surfaces, this progress will eventuate in a refinement rather than in any major change in our concepts of reaction rates. That's a prediction -- it might not be true.

This experience highlights certain conclusions. First, the innovator must usually find his way by means of unfinished bridges. Also, in science, as elsewhere, the blazed trail precedes the broad highway. Finally, the development of the theory of absolute reaction rates illustrates another fact observed many times before. One's successes are always related to and built upon the findings of others. Creativity in science, as with most human enterprises, prospers most in a friendly atmosphere of cooperation.

The creative environment

Looking back over experiences at the Universities of Arizona, California, Wisconsin, Princeton, Utah and the Kaiser-Wilhelm Institute in Berlin (they passed me on as fast as they could), it is clear that really interested investigators were never stopped from doing research by difficulties. There is always a way. At Arizona, Ernest Anderson worked early and late singing hymns and extracting the various sugars from the gums of all kinds of desert plants, while Professor Douglas intrigued the world with his tree ring dating. Later at Berkeley in G. N. Lewis' laboratory, there was no place for scientific onlookers. Everyone did research and comparatively little teaching. My one and only formal course in chemistry for the Ph. D. degree was thermodynamics. This was in spite of the fact that my earlier training was as a mining engineer and metallurgist rather than as a chemist -- it didn't bother them at all. The preliminary examinations were perfunctory, but the minor in mathematics involved taking a substantial amount of classwork. In spite of a belief in light teaching loads for the professors, it was recognized by Lewis that freshmen at the beginning of their career respond to expert teaching. This teaching was provided through the general chemistry lectures given by Joel H. Hildebrand. In addition, every professor was expected to teach one laboratory section of freshman chemistry. In this way even the freshmen were thrown into the company of accomplished scientific investigators. The results on the students were interesting to watch. Some students who would otherwise have passed chemistry by elected it as their life's work.

The stream of outstanding physical chemists turned out by the G. N. Lewis school at Berkeley includes three Nobel prize winners. The success of Berkeley has frequently been cited as establishing the superiority of a system in which the entire emphasis was on research to the exclusion of course work. This too facile explanation leaves out of account the very significant fact that Lewis' fame and the high quality of his staff attracted a substantial fraction of the best talent available. With such a clientele, most systems would have succeeded. The fact remains, however, that at Berkeley, graduate students mingled with outstanding scientists who entertained no doubt that intelligent research was the most important activity in the world. This contagion infected everyone. Individual success in research was accompanied by a shedding of any undue veneration for the "embalmed" science of the past. Seminars led by Lewis were always exciting.

Another point was significant. The new graduate student was given keys to all of the stockrooms. This was in fact a presentation of the "keys to the city." With this handsome gesture went a few words on acceptable conduct. So far as I remember, people responded to this generosity admirably. The chemistry department at Berkeley was, in fact, a society of scholars. Successful research was the badge of honor. To not try to do research was unthinkable. The research atmosphere provided at Berkeley has probably rarely been equalled.. Granting this, I, nonetheless, would have added a few more courses and made the preliminary examinations more searching.

Winconsin in 1927 was good but different. It was much more decentralized. Daniels and Adkins, among others, were nuclei around whom good men gathered. Courses were more numerous and preliminary examinations harder. The research fund provided by Steenbock's patents on food irradiation paid for research fellowships and equipment. In its best fields Madison rivaled Berkeley.

Geheimrat Haber's Institute in the Kaiser Wilhelm Institute of 1929 also sparkled. Haber's poor health did not prevent his making incisive comments and he surrounded himself with Europe's top scientists such as Freundlich, Polanyi, Bonhoeffer, Fritz London, and Eugene Wigner. The facilities were good and the personnel the best. Again there was freedom, encouragement, and good library facilities. Chemical research at Dahlem was high adventure.

A stimulating year in Berkeley (1930 - 31) was followed by fifteen years at Princeton. Here one saw an exciting research center not quite like anything that had gone before. A quota system restricted graduate students in chemistry to twenty-five. This could be stretched to thirty students (this was bootlegging, but it was done). An excellent supply system provided everything needed to work with by signing for it. Seminars were frequent and lively. H. S. Taylor was particularly effective in focusing discussions on the essential point in any scientific discussion and everyone entered freely into the discussions. More course work was required than at Berkeley, and Ph. D. preliminary examinations were more searching. The graduate students again were excellent, since only about ten could be accepted from a hundred very good applicants. Here again everything that would stimulate the creative process was used.

The last eleven years at Utah have been concerned with the setting up of a Ph. D. program and watching it grow. Because the foundation had been well laid earlier, this has been a pleasant, successful operation. Our program more nearly approximates that of Princeton than the one I knew at Berkeley. About fifty Ph. D. candidates in chemistry work as teaching fellows, as research fellows, or on various supported projects. The creative atmosphere we are seeking is a spirit of friendly, active cooperation.

The future outlook for creative investigation

Chemical investigation in this country has been stimulated tremendously by the money invested in research by government agencies and by the high income tax laws which prompt industry to strengthen its position by plowing back into research some of the profits that would otherwise be partly taxed away anyway. Out of our present tremendous research effort, which in the best interests of society should be doubled, we are nonetheless witnessing a material advancement never even imagined before. Even to mad men, if must be clear that world-wide cooperation in creative research could solve our economic woes and that following any other course may lead the world to destruction and unimaginable human misery. To be optimistic of continuing success in the current tremendous creative effort requires only the faith that mankind is not insane. With the unlocking of atomic secrets man has acquired the capacity to make the world uninhabitable. Society can not now allow power over atomic forces to fall into the hands of any single individual, since in that case human existence will hinge on the slender thread of one man's sanity. Genuine democracy with its checks and balances has an urgency about it in these days of mortal peril which never existed before. I firmly believe that society will succeed in continuing its creative advance because the alternative to this is irreversible disaster to everyone.

Q--I have some comments that I would like to make. I think in my earlier university days I was one of Dean Eyring's balky horses. I wanted to present a thought here for Dean Eyring's consideration in particular based on Barron's presentation yesterday on the needs for order and disorder as motives for creative thinking. This presentation led me to consider the possibility that information theory, or more specifically the mathematical theory of communication, can be applied to the problem of the measurement of creativity. Barron pointed out that the situations involving highest disorder were conducive to creativity. This is exactly the situation involved in information theory, wherein the amount of information is measured by the disorder present. In this theory the word "information" relates not so much to what you do say as to what you could say -- that is, information is a measure of your freedom of choice when you select a message. It would appear that the action of creativity is essentially an action of communication, regardless of the medium. The mathematical theory of communication is so general that one does not need to say what kinds of symbols are being considered -- whether written letters or words, or musical notes, spoken words, or symphonic music, or pictures. The relationships it reveals apply to all these and to other forms of communication. Perhaps you would comment on this since the negentropy principle of information theory is an outgrowth of thermodynamics and statistical mechanics.

S--I'm sure that's true. Information theory as we know it is a formalization by Boolean algebra of a lot of things that went before and has been popularized by recent developments. The definition of the unit of information is new and it has a formal garb that I am sure will become very useful. I think that it is not a revolution, however, in the sense that it is anything more than making quantitative the kind of things that people did before. It is a very useful mathematical systematization and I am sure it will have lots of effects, but I think it is just a method. Perhaps some would feel different about it. The thinking of information in terms of bits is useful and the economy of thought made possible by applying mathematical analysis to psychological concepts will be interesting to watch.

Q--I wanted to ask you something about this Berkeley situation. It happens that I have heard this story about the system at Berkeley before, because a number of the men in my sample when I studied scientists were trained there. Obviously you do not follow the Berkeley system completely here because you have more courses in your area. Would you suppose or do you have any inclination to go back to the Berkeley system, and if not, why not?

S--I think it would be atrocious without a Lewis. The only excuse for it was that they got the best people, and I think the point usually made as to how well it worked is just exactly wrong. The system at Princeton is much better. The only reason the Berkeley system worked is because no system could fail with the people they had. (Laughter.) If you select the students well enough you cannot possibly ruin them except by frightening them so that they quit being creative -- like you balk a horse. I think it was because Lewis was disinterested in routine things and he liked to think mainly about his own research. He was very successful at it; he got some interesting people around him; and he had a system that would work every time you pick the best people in the country. And it will fail every time that you do not. That's my evaluation.

C--If the system pulls in the best students, that is at least in its favor.

S--That's right, because they put in enough money to get G. N. Lewis, and got other first-rate scientists. You could go down to the Belgian Congo and take the best faculty in the world down there, and pretty soon you'll have a fine university, because people will come as far as they must.

Q--As you described the environments in these different places, one of the things that seems to emerge from it is the rather quick acceptance of the individual as part of the community. One of the things I have been wondering is how is it that in France and Germany, which are highly authoritarian societies, they seemed to produce so many creative individuals. Yet as you talk about your experiences in Germany, you mention a rather quick acceptance of you by what you have regarded as very eminent people -- that you were thought of as a person who could think with them, rather than a person who was to learn what you could say to them.

S--Well, isn't the conception of science when it flowered in Germany completely the antithesis, that is, academic freedom was stronger there than at any place in the world and a man like Haber didn't answer to anybody for things. He had a position. I suppose we all know who he was. He was the man who was responsible for the ammonia synthesis and made the first world war possible. Without Haber's discovery of the synthesis of ammonia, the Germans could not possibly have risked the first world war. He had a position and nobody questioned it. So I think that when Germany did flower, and it surely did, that no matter what their political government was, in scientific things they had about the freest kind of idea of academic freedom that has ever existed. I don't think the United States has ever had greater academic freedom.

C--I was thinking more of the relation between faculty and students. In other words, were you able to communicate with these people, to interact with them, or was the position of the student one of absorbing what the people "on high" might say?

S--I went to the Kaiser Wilhelm Institute, which was a research center, and there the relationship with Polanyi, with whom I worked directly, was the easiest possible kind. A typical remark was "Well, let's both speak English, so we will understand each other." This was a very great help. But then the university had democracy; you did not have to go to their classes. The professor was on a pedestal, and I think that was probably bad, except that it gave him time to be creative, and it brought in the best people. I think the status given to professors in Germany was a tremendous thing -- they really had their best people in this work. I think that the United States suffers from not giving more status to professors, hence we do not always get our best people in the university. I think Germany very nearly did, and that is surely another element that goes along -- how much you lose in giving status and time for research and then putting the professor on such a pedestal that he is unapproachable. But the German system worked tremendously well, at least in the time when the Kaiser was running things.

Q--Would you characterize the difference between a creative teacher on your undergraduate level and your graduate level?

S--I think one of the best things for a creative teacher is that he looks kind of dumb to his students. If you look and see where they get many students in chemistry it is not in the big universities -- they hardly get anybody to go into chemistry -- and yet most of the research work is done in the big universities. It is done by the people who live with the students -- who are friendly towards the students, and who do not look too far away. I think if we frighten students in our educational system we do not make good pulling horses. I think that you could not scare away the few geniuses who are aggressive and go ahead, but a lot of people who are really very bright, that would make very good people, do get frightened away by austerity, by the man in his effort to get status -- of trying to look good. I think if a man would try to not look good, but was really good, that would be the ideal teacher -- that is, a man who really pretended nothing, who prepared his lectures and saw his students. I remember one man who never prepared his lectures and they were horrible because he thought that the important thing was for the students to see him make mistakes. But he had underestimated his natural ability along this line. That is, he could make quite a few mistakes without working at it. (Laughter.) Too many mistakes can be bad too, but at least to look human, and make people say: "Well, if that man can make a success as a chemist, there is nothing to stop me." I think this is a very important thing.

C--A number of years ago I talked to a director of a chemical laboratory and the question I asked was: "What occurs during graduate work in chemistry that enhances or contributes to the man's creativity in your laboratory later?" He laughed and said, "My experience is that it takes these men about three years to recover from the effects of their graduate experience." He said, "Of course, it's necessary. Don't misunderstand me." His thesis was that much of what we do in graduate work tends perhaps to produce too critical an approach in the person.

S--I'm kind of reckless with names, but I think Harvard does a faulty job in one particular respect. Though I've been there a number of times, I don't know them intimately, but my impression -- in chemistry again -- is that there arose a tradition of perfectionism -- never publishing anything until it is done perfectly to the last decimal point -- which I feel can spoil more people than it helps. I think that because they get such a big proportion of the best students they turn out very wonderful people in chemistry. I think that almost any system would do better on this particular point. A man who seeks status, who wants only perfection, and who tries to be sure that each paper is the last thing, who struggles over the thing and tries to make his students produce the Nobel prize with their first paper, is apt to make balky students. He forgets that a hack like Shakespeare really did quite well just writing all the time.

Q--But you do believe in a man reworking material?

S--I think if you want to be creative the best way is to do something, because the whole world loves to cooperate with you at least if part of it is to cut your head off. I think that the same things which make a good businessman make a good scientist, that is, that he will undertake things -- that he will do things -- and everyone is willing to cooperate with him on the basis of knocking him down. I don't think you should publish everything, but more good people are spoiled scientifically and in their creative thinking by being frightened than anything else -- at least, this is the way it seems to me.

C--You had some personal contacts with Einstein. Do you want to make any comments about his characteristics?

S--I did not have very much contact. He was at Princeton, of course, at the Institute for Advanced Study during part of the time that I was at Princeton University. We all have the same impressions, namely that Einstein was just first rate. I do not think anything could have spoiled him. A vital thing was his natural ability. I think that is the important thing, to look after the genes and everything else will take care of itself if they are on a high enough level. I don't know what else to say about him. Let me tell this story which is of comic value -- maybe that is the main value of my whole talk.

A man on high explosives from Washington came over, and Einstein was theoretically interested in high explosives during the war. Actually, he was not greatly interested in it, but we went over to talk to him through the morning, and even in subjects that he was not specially interested in, he was always acute. In chemistry, which he did not pay much attention to, you still find few people who are more interesting to talk to, but the story I want to tell is interesting. After talking through the morning about high explosives, we went out and walked along a path through the beanpatch that was in front of the Institute for Advanced Study. As we walked along the path, it was pretty clear to me what the patch was because I have hoed all the kinds of beans except soy beans. I reached down and picked up one, and I asked Professor Einstein what it was. He said "I don't know." We went on up to the end of the path and there was a gardner sitting on his wheelbarrow, and I asked him the same question and he said, "Oh, those are soy beans." This incident seemed to me to bring out an interesting point, which is that the best scientist in the world, and I think that's a fair way to describe Einstein, can't solve problems either if he doesn't think about them. He had walked through that bean patch four times a day since it had been planted and hadn't solved it, so it really showed his degree of abstraction on other kinds of problems. Of course, I'd much rather have had the gardner for a partner in the raising of soy beans. (Laughter.) But the very high degree of abstraction, which that does show in Einstein, surely portrays his concentration and economy of thought -- he really took hold of things in which he was interested and worked with them, and was concerned with them to the exclusion of all else -- even to the exclusion of the beans.

A CONCEPTUAL MODEL FOR INTEGRATING FOUR APPROACHES TO THE IDENTIFICATION OF CREATIVE TALENT

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Four Approaches

S--While sitting in on discussions of creativity, I have found what seem to me to be four significantly different approaches to the problem, depending on which of four aspects of the problem a person uses to gain his initial hold, i.e., the aspect of:

1. the product created, or
2. the process of creating, or
3. the person of the creator, or
4. the environment in which creation comes about.

Each of these aspects affords a different approach to the identification of creative talent; each has a different ultimate criterion; each is likely to have an appeal to a different group of people.

1. The approach through products created is likely to be favored by those who are taking responsibility for the consumer's or society's welfare, such as the administrator of a business enterprise or of a public institution. It is the products of creation which can be shared among people. Individual creators are acknowledged as important, of course, but their importance lies not in themselves, but in what they create. To such a perspective, the ultimate criterion is therefore the product. The way to proceed in selecting talent is to first get criteria for creative products and then move back from that to the identification of those who produce them.

2. The approach through the process of creating is likely to be favored by those who are themselves creative individuals, e.g., painters, novelists, dramatists, musicians, sculptors. It is from sharing in intimate understanding of how other creative persons handle themselves during creation that an individual creator can gain some added wisdom for the heightening of his own creative capacity. To such a perspective, the ultimate criterion is therefore the psychological frame of mind which best serves the creator in handling himself productively during the process of creation. The way to proceed in selecting talent is to first get clear on the necessary frame of mind and then to find persons who show capacity for using and cultivating that frame of mind.

3. The approach through the person of the creator is likely to be favored by those who are responsible for picking individuals to fit particular positions; for example, the personnel psychologist and the personnel manager. The normal approach of personnel men is to define the job to be filled, find persons who successfully fill such jobs now, discover the extrinsic signs which mark off such persons from others, and then go into the labor pool to find individuals who show such markings. The ultimate criterion, in this case, is the pattern of extrinsic signs which marks the creative person. The way to proceed in selecting talent is first to get clear on the pattern of discernable signs which will empirically separate one person from another in the direction of creative talent,

to continually refine that pattern and use it to select persons out of the labor pool.

4. The approach through the environment is likely to be favored by those who are responsible either for the continuing care and cultivation of personnel, or for the explanation of changes taking place in persons because of cultural or physical surroundings. Among the former are teachers and managers; among the latter are sociologists, anthropologists, cultural historians, etc. The teacher or manager cannot get into the physical interior of those to be taught or managed; his influence is restricted to what he can do on the outside of the person to be influenced. In education, this gets the teacher into problems of how to teach, how to build curricula, etc.; in management, this gets the manager into human relations problems, training programs, shop arrangements, etc. Among sociologists, anthropologists, cultural historians, etc., the problem, by definition of professional task, is that of discerning what pattern of circumstances around individuals or groups accompanies what patterns of behavior in them. The ultimate criterion is the pattern of circumstance necessary for releasing creative production. The way to proceed in selecting talent, for these people, is to first get clear on the environmental pattern required and then either provide environments with such patterns so that persons can become creative within them, or go find already made environments having such patterns, wherein there will already be creative persons.

These four approaches are not only different but, apart from high levels of sophistication, they also tend to be antagonistic to one another. The administrator's avid interest in products (Approach No. 1) can threaten a creative producer (Approach No. 2) because it is fatal to the act of creation for the creator to become product-centered while creation is still under way. Creative artists have learned this, often at great cost to themselves; for them to hear a status-bearing administrator talk about the importance of the product is to threaten them at a tender spot. The creative producer's emphasis on process (Approach No. 2), in turn, is a threat to the personnel worker (Approach No. 3) who says, "Don't gum me up with this talk about a hidden process of some kind; what I need is the extrinsic, evident stuff I can find in people when I test them on my own terms, using criteria I know to be required by the job situation." The personnel worker's emphasis on extrinsic signs for identifying creative persons (Approach No. 3), in turn, is a threat to the environmentalist (Approach No. 4) as, for example, in the case of the teacher who says, "Don't confuse me with your system of extrinsic signs because they won't work to help my thinking as I try to teach; I have to concentrate on signs of intrinsic development in children while simultaneously using extrinsic environmental influences to challenge the children to grow. If I can teach creatively, I can pick the creative people simply by noting those who respond to the teaching." And so on, through the roundelay, one can go, realizing how it is that each approach in turn is threatened by three others.

This condition of affairs may account for much of the confusion occurring in group discussions of creativity and in the literature on the field as a whole. The need is for a way of taking hold of all these perspectives at once so that each can serve and support rather than threaten the others. To accomplish this goal, it is necessary to come to a perspective which is large enough to encompass all four within one system and deep enough to establish the interlocking function of all four.

I have tried to create such a model, one version of which is developed and presented in the next section. It puts together the four approaches by showing them to be aspects of one unifying idea. This idea has had a slow growth over several years and has come into realization, in part, because I have, at various times, without feeling split, carried all four kinds of social roles (i.e., the administrator emphasizing product, the individual creator emphasizing process, the personnel officer emphasizing the person, and the teacher and student of contemporary cultural conditions emphasizing the environment). Not feeling split while still sensing the distinctions, I was driven to find an underlying structure of thought which would unite all four while yet giving place to their distinctions.

It has seemed to me, over the years, that nature, looked at rationally, is put together according to order. We should be able to think our way through many problems in the social and biological sciences if we could only get hold of a germinal order pertaining to the forming of life structures. What is the logic in "bio-logic?" What is the logic in "psycho-logic," "socio-logic," etc.? What is the intrinsic order of emergent life? If we could postulate an answer to this question, we might be on our way toward providing the social and life sciences with the kind of conceptual strength which mathematics provides the physical sciences. Hence, the search and the postulation has occurred and is expressed here in terms of the essential conditions for the existence of men.

A Conceptual Model: Essential Conditions for the Existence of Man[1]

Let us begin by drawing a big broken circle to represent the universe (Figure 1). The breaks offer a way out toward infinity and yet there is enough of a circled togetherness for us to take the universe as a graspable whole. Within the universe are a multitude of energy forms -- rocks, seas, air, earth, tides, winds, animals, vegetables, minerals, atoms, molecules, radio waves, etc. -- all in intricate interconnection, all one synchronous system, composing, changing, and recomposing constantly. These energy forms are denoted, in the drawing, by the multitudinous miscellaneous forms within the circle of the universe.

One of these forms is drawn as a broken circle to represent an individual man -- you or me (Figure 2). If it were drawn to scale, it would be the tiniest speck, indeed, for the relative space one of us occupies in the universe is very, very small, and the relative time one of us lives is hardly an instant, taking the vastness of the universe into account. But the speck does exist and is important to you and me. So we make the inner circle big enough to be seen and seriously confronted.

What the placement of this smaller circle inside the bigger circle says is that we are in the universe, not out of it; we are of it, not apart from it. We are born, we live, and we die in it. Everything we do, or are, or become, is synchronous within the total system. Our relations run to all the other energy forms in the universe, in one dependency and belonging. Symbolizing this relation, we draw arrows pointed

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[1] A considerable portion of the development and expression of this conceptual model has been drawn from the author's previous work and writings, as cited in the list of references at the end of the total report.

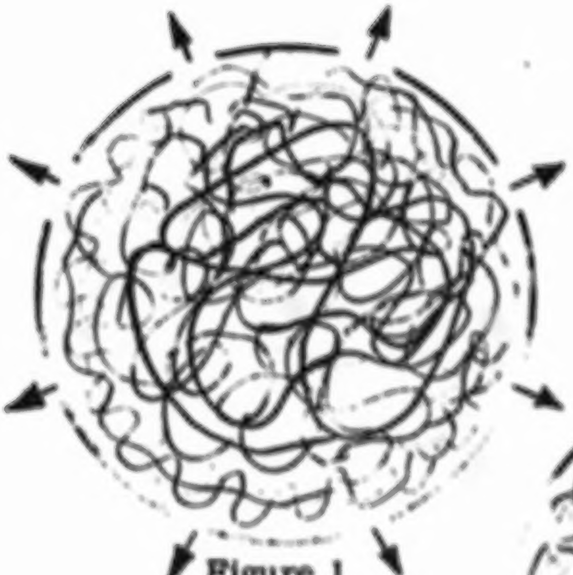


Figure 1
Composition within Universe: Energy Forms in Action

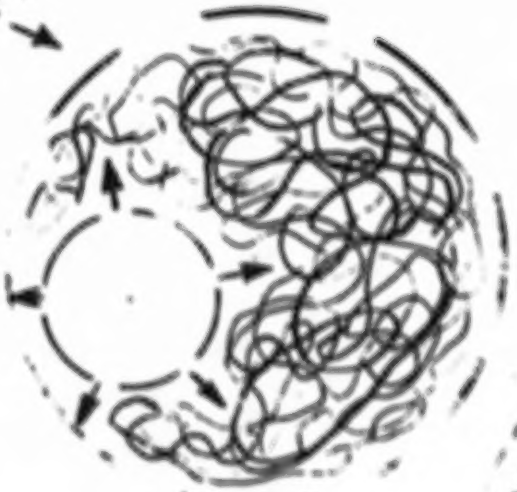


Figure 2
A Man's Outward Relation to Other Energy Forms

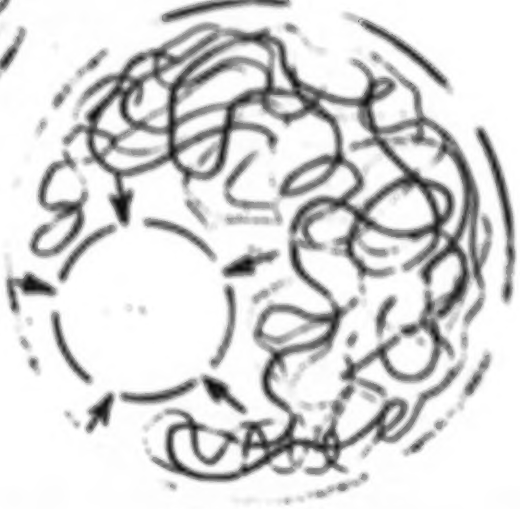


Figure 3
A Man's Inward Relation from Other Energy Forms

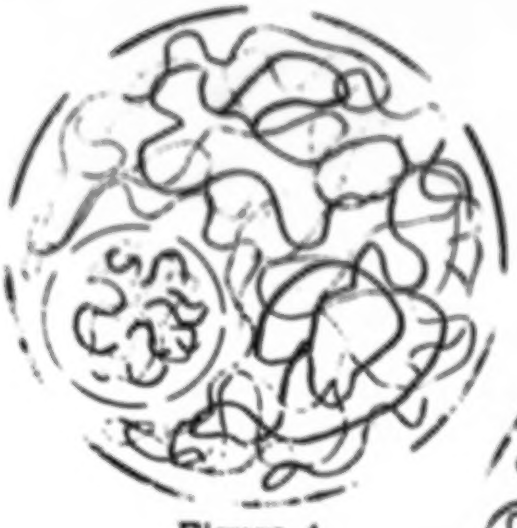


Figure 4
Composition within Man: Energy Forms in Action

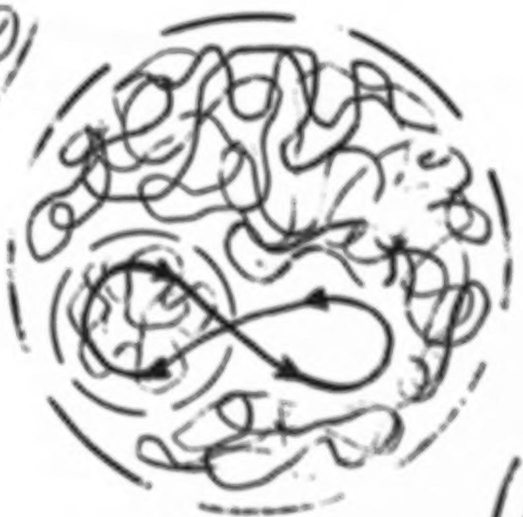


Figure 5
A Man's Sequential Transaction with Other Forms

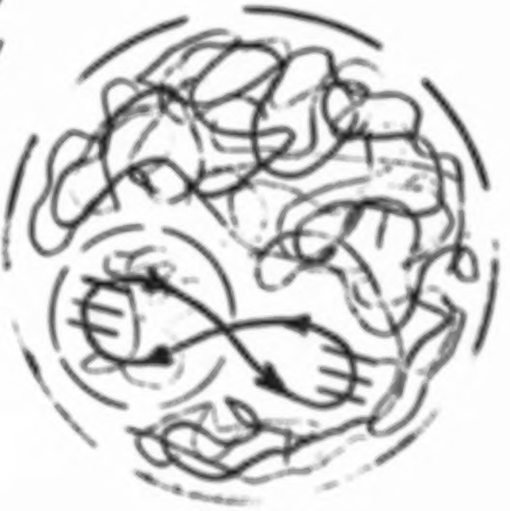


Figure 6
A Man's Selective Fitting during Transaction

outward from the circle of man into all the rest of the universe (Figure 2). These outgoing arrows stand for the first of the four essential conditions to which I would call your attention.

Outgoing relations have their concomitant relations coming in, for, not only does a man extend outward toward all else in the universe, but all else comes in toward a man as well. His existence gives him a time-space spot to be in, and, at that location, all the universe comes into focus. A man perceives the universe, acts in it, organizes it, comprehends it -- all from the locus of his being, his time-space location. To exist is to have this being, this unique organizing spot which is one's own and no other. Other beings occupy their respective spots. Each being, in turn, composes the universe from its particular location. The universe as a whole is the togetherness of all these being-positions. To signify this very significant second condition for the existence of man, we draw arrows from the universe into the circle of man (Figure 3) complementing those that we had drawn outward to show the opposite relationship (Figure 2.)

Inside the circle of man, there is much going on: blood circulating, food digesting, neural impulses traveling, muscles tensing and releasing, glands functioning, atoms dancing, etc. Each of us is a multitude of these energy forms, all in synchronous relation as a system, all forming and reforming constantly. Maintaining oneself alive depends on keeping these goings-on going on as a system. When this ceases, one is not a being any longer. To show this inner action in man, we put inside his circle a multitude of miscellaneous forms (Figure 4) as we had already entered these forms in the rest of the universe (Figure 1).

Keeping the goings-on going on inside the system depends upon synchronous relations with goings-on outside the system. It is necessary to take in freshly usable energy forms from outside while energy forms are being transformed and expended from inside. This is well represented in daily life in the inhaling and exhaling of breathing, the eating and elimination of digestion, and the perceiving and acting of conscious behavior. There is a constant giving out and taking in by the organism, a continuous transacting across the borders of a man to give sequential and orderly form to what goes on between inside and outside. This sequential, orderly flow is symbolized by drawing an arrowed infinity sign between inside and outside, having its center at the border of a man (Figure 5). This sign suggests the third essential condition.

Reaching-out and receiving-in on the infinity sign cannot be blind. This activity needs to be selective. A man cannot eat all things, or at all times, or at all places, or in all ways, or for all reasons. Neither can he breathe everything, perceive everything, do everything. He's not an elephant, an ant, or a blade of grass; he is the particular form called "man." Further, he is not all men, but the one man he is. This one man is not even all of himself at once, but only himself at-each-particular-time-and-place as his life moves along. Each act has its necessarily specific fitting according to what each man's system then and there allows, invites, and requires, according to what his environment then and there offers, suggests, and permits.

This constant selecting on the part of a man works toward:

1. inclusion within his system of what is needed,
2. exclusion from his system of what is damaging, and
3. toleration of what is left over -- the remainder. To symbolize this important

selective operation in the drawing, we add three lines to both ends of the infinity sign to denote the three basic choices -- inclusion of the needed, exclusion of the damaging, and toleration of the remainder (Figure 6). This represents the fourth essential condition for the existence of man.

To summarize in the language of dimensions, the essential conditions for the existence of man are that he be able to operate with respect to:

1. out, denoted by the outgoing arrows, to declare man's extension into his universe, his belonging to the whole;

2. in, denoted by the incoming arrows, to declare man's centrality in his universe, his being integrative to the whole;

3. out-and-in-and-out-and-in-again-and-again, denoted by the infinity sign, to declare man's sequential ordering of his universe, his continual coming to be (becoming) through give-and-take, incoming and outgoing;

4. fit, denoted by the three lines at each end of the infinity sign, to declare man's selective ordering of his universe, his continual fitting of specific incomings and outgoings, his rendering potentialities actual in concrete sequential instances.

These are the four dimensions which have come to be fundamental in my "logic of life," in one form or another. This specific expression of the model came in the course of work on perception. The problem of perception is the problem of how a living being goes about its transactions with its environment so as to make emergent life possible. It was necessary to see perception in the context of the four dimensions in order to hold a field of explanation for laboratory events. To do this was to see perception as a creative phenomenon, fitting into the essential conditions for the existence of man.

Over the years there have been many other contexts in which I have tried to realize life-forming. One of these has been the biological. I have looked to see what biologists seem to feel they must cover before they have a well-rounded picture of a living being, and I have found them talking about: (1) the environment, (2) the creature, (3) the transactions between the two, and (4) the consequent adaptations. Looking into evolution for the progression that men have found in moving from the simplest protozoa to the complexity of man, I have found what appears to me to be a dynamic ladder by which the climbing has been described: (1) the development of an increasing openness to wider reaches of the environment, (2) an increasing centering of action within the organism, (3) an increasing span of sequential ordering, and (4) an increasing selectivity, all four of these operating as one tension system, a development of one (encouraged by specific environmental circumstances) in turn requiring the development of the others. Life has thus been able to evolve its increasingly complex forms.

Coming into the assumed peak of evolution at the opposite pole from simplest biological life, I have studied what highly creative people seem to do to cultivate their peak of creative experiences. It has seemed to me that they seek: (1) to hold themselves open for increasing inclusions within their experience, (2) to focus their experience through self-differentiation and self-realization, (3) to discipline themselves in order both to extend their opening and refine their focusing, and (4) to derive significance from their experiencing through dependence upon increasing esthetic sensibilities. The basic structure for realizing and cultivating life at the psychological level is thus the same as for realizing and cultivating life at the biological level.

In further study of man's efforts to cultivate vitality in himself and his works, I have asked artists to tell me what they must have in their particular medium of expression to have the basis for a living creation. The dramatists have said that, in their medium, the elementary conditions are: (1) a setting, (2) actors, (3) action, and out of those comes (4) the play. Painters have said that, in their medium, the elementary conditions are: (1) ground, (2) figure, (3) tension, and out of these comes (4) the painting. Musicians have said that, in their medium, the elementary conditions are: (1) harmony, (2) melody, (3) rhythm, the fitting of which makes (4) a song. It seems reasonable to me that all the arts will be found to have a similar basic structure.

Turning to cultural matters, studying the development of American life and then the longer sweep of Western European civilization, it seems to me that: (1) we have pushed for ever wider inclusions (of land, of natural resources, of technological power), which (2) in turn have pushed for greater centralizations (in larger and larger economic, political and social units), which (3) in turn have pushed for increasing regulatory orders to tie together more actions in sequential systems (increasing systems of law, regulations and customs), which (4) in turn have pushed for more communicative connections to render more refined and extended judgments of the fittings being accomplished within the culture (increasing communication lines with increasing energy given to asking deliberate questions and seeking deliberate answers, most sharply suggested in the development of research). To me, these cultural developments are all within one self-generating system which is tied into life-forming. Culture is a life creation, too.

In clinical psychology, I find therapy to be a process which is aimed at increasing the client's: (1) openness to wider ranges of experience, his ability (2) to integrate the widened inclusions into one understanding, which (3) increases the range of his controls and (4) provides him with the greater satisfactions of a more fitting and fulfilling life. Therapy is a form of life taking place and should follow the basic laws of life. So also with learning. Learning is a name for: (1) including something new into the field of the known, (2) giving it meaning by making it the means to a fresh integration of relations in the field, thus (3) to expand the action-control possibilities of the learner, and (4) to refine the fittings of meanings in the learner's experience. And so it goes, including the religious, which seems to emphasize: (1) a wider belonging in the universe, (2) a more vivified being, (3) a more assured and longer-range becoming, and (4) more of the beauty and glory of life-fulfilled in its most refined realizations.

In life everywhere, whether it be in perception, in biology, in highly creative experiences, in art forms, in cultural developments, in clinical psychology, in learning, or in religion, the same thought-model sooner or later emerges for me.

It is therefore to this model that I turn again when trying to find a deeper ground in which to visualize the research work which has been done to identify creative scientific talent. As you will remember, we pointed out that there were four main approaches which had been developed, those emphasizing: (1) environment, (2) the person, (3) the process, and (4) the product (consequent significant fit), although presented in the reverse order in the opening exposition.

I close with the proposition that we should be seeking this deeper ground, and that it is into this region that we need to go in order to clarify what we each are doing as it relates to the work of others. To become a team, we will need to know the respective positions we play in the same game, and to know the game, my hunch is that we will have to listen hard to what "nature" issues through life and through us as the rules by which the game of creation is carried on.

While to presume any connection with creation is audacious, I have learned that it is only by daring to take part in creation that one can consciously help himself to become a vitalized part of it.

C--I am extremely pleased with this report. I might explain that very much the same sort of thing happened to me. The year when my husband was writing some books, one of which was a textbook in biology, we stayed at our home and were snowed in during the winter. I finished a book on the making of a scientist and started writing a paper on the creative process, which I never published. However, what happened was that in reading each other's work at the end of the day, it dawned on me that the creative process, as I understood it from my studies of scientists and painters, was no different from the basic biological functioning of protoplasm, namely, selection, assimilation, and production; I could express the whole thing in these terms. This is why, since then, I have always said that we do not have to teach people to be creative; we just have to quit interfering with their being creative because this is the way one gets from protoplasm to the nervous system, this is the way the nervous system functions, too, and perception fits in perfectly with the pattern.

I stewed about this for some time and then I began worrying about the evolution of behavior and began trying to trace what we knew about lower organisms in terms of the evolutionary sequence; I wrote a long paper on the evolution of behavior and sent it around to a few people and got my ears beaten back. So I said, after all, I do not know very much about this and neither does anybody else, but let's find out. With my husband's assistance and ardent cooperation, we talked the Society for the Study of Evolution into sponsoring such a conference, and I talked the APA into sponsoring it, and we had a joint conference; NSF supplied the funds, and Rockefeller Foundation also gave some funds to get it started. We have now had two conferences on the evolution of behavior, involving geneticists, biologists, psychologists, etc., and the symposium volume on the second conference has now gone to press.

The thing that started it was my getting involved in precisely the sort of thing you do. I think it is extremely important that we appreciate that the process of reacting to the outside world is as you say and that this is basically the same thing as the creative process. When it happens to eventuate in a product which is detachable from the producer and usable by others without the producer's being present, then you have what we term, socially, a creative product. I think the implications for education and for many other things are very different from what they are if we assume that there is a specific form of behavior, a specific group of special faculties which are necessary. Now the forms in which the products come out and the usefulness of the product to society depend upon these other factors, but I am firmly convinced that the basic process is merely the basic process of life. I am very happy to hear you say the same thing.

C--I don't agree with this business that it is not a matter of teaching people to be creative or facilitating their creativity, but rather simply not stopping them from being creative. I don't think that is an accurate statement even in terms of this model, because what deserves to be said is that the first need of the human being is to establish a boundary and to maintain it. The function of the ego is to establish and maintain a properly permeable boundary.

C--Emphasize the "properly permeable."

C--Yes. The fact that the system is born with various exits and entrances might lead to the error of thinking that the more open the system the better, whereas the actual thing is that the system has to exist by being able to shut off itself from the outside.

S--Yes, that is important. That is why I say that the being is just as important as the belonging; you don't have any belonging without a being, no opening without something to be open from.

Q--And the befitting is what you would think about as the proper permeability.

S--Yes. I think that these highly creative people really try to open themselves in a certain sense, but not to everything, because they would go to pieces if they did. They've got to put borders on what they give attention to and then open other places wider and wider. This is what they are trying to do with the ceremonies they go through in cultivating their creativity. Paradoxically there is both a wider openness and a clearer definition of being.

C--That's the problem that I was really wrestling with in that "order and disorder" discussion because too much openness to disorder results in disintegration and the ending of the system.

S--Yes, that is why all we need is an "approximate togetherness," (a circle made with broken lines). I still have to hypothesize that there is something beyond the reach of the person because every circle that has an inside has an outside. I have to put boundaries and then know that beyond that, there is something else.

C--In those extreme cases where superior intuition really occurs, as in mysticism, what happens is almost a total eclipsing of the boundaries for the moment in a sense of total participation with the universe; that is, when you have genuine mysticism and not the hysterical dissociative pseudomystical experience. But in genuine mysticism I think it is the extreme limit of permitting the boundaries to disappear and then the capacity for that is one of the marks of creativity of a high order.

Q--Are those only internal boundaries to the system?

C--They are psychic boundaries. I am referring essentially to the boundary which distinguishes subject from object, the first distinction made in the course of development of the sense of reality.

Q--Would you say that a truly creative person was one who had complete control of his reactions, that is, the person who can control what he gets from this outer part? Isn't that a very important thing in the stability of life?

S--I wouldn't try to answer the question this way. I have a feeling that a person gives himself to an ordering process that somehow makes such good sense to him that he is willing to let the ordering process move. This is the way one adventures, whether it be into the unknown of ideas or with the pioneers who first gave themselves to the adventure of crossing the Rockies; conscious control is in it, but so is conscious giving of oneself to a process.

Q--I was thinking that certain events in life will knock some people for a loop and others will grow under it and will be better off from the crisis. Is the creative person more apt to control his reactions to these crises in such a way as to result beneficially to him? Is that a characteristic of a creative person?

S--I would like to modify that question. I do not want to speak of the "creative person" as an entity that is separate from all other persons.

Q--Does your model really provide any account for individual differences? If so, in what way? Let's take individual A and individual B. How do these two differ in terms of the model?

S--Each individual has a different location, and each one organizes from his different position so they have to be different.

Q--He is different because he is in a different place in the universe?

S--He is a different being--that is number one.

Q--What in the model represents the difference between those two beings?

S--I will give you the quickest answer which to me is "mathematically" satisfying; the universe has bunches of points in it that are right there delivered to you.

Q--Yes, I am different because I am at a different point in space-time. But if people differ in creativity, they must differ in terms of characteristics which must find representation in this model? Is it the degree of openness?

S--Then you must introduce change, over time, in learning.

C--Put it on a simple sensory basis. Some people are able to perceive a wider range of auditory vibrations. Therefore, the number of sensations they can experience are different from others. There may also be a difference in intellectual competency, of the things they can actually take in and use. So the degrees of openness are dependent upon their own capacities, to some extent, quite apart from their willingness to be open. Some persons are unable to perceive certain things. You can't perceive some things that bees can perceive because you haven't got the right set of sensory organs.

C--Yes, I see what you have said but I don't see how the model described allows me to do any more about that than I could do before I had the model.

C--On this matter, if creativity is universal, I wonder if clarification might be achieved, by saying that form and meaning and structure are the design in which we all determine our movements. Whenever we move psychophysically, our organization goes through some orderly process; this is our being. But the orderly process is largely determined in the stereotyped people by the forms, the meaning, the constructs of the universe of meaning or the cosmos or meaning which surrounds them, which they have accepted, and which is the spiritual sphere of their realization. Freedom of form, meaning, and construction, (that is, freedom of configuration) guarantees freedom of being. If there must be an inward gesture, it will either be stereotyped or it will make free use of the existing forms and meaning and will make the necessary alterations in them. Does this seem to be a reasonable expression of it? It seems so to me. That would make creativity universal if it is free for use and activation unless it is prohibited by stereotyped behavior imposed in one way or another.

Q--I take it that what we have here is a theory of the creative process. I wonder if it has been stated in a way which makes it testable? Are there hypotheses or implications of it which are testable and which would make it comparable to some other theory of the creative process?

S--The testing process for me has been to subject myself to different possibilities in different areas, biology, perception, the arts, etc. This is a kind of conceptualizing test, but it is related to a lot of human experience; the arts, for example, have had their basic essentials for generations. The model squares with these essentials.

C--It isn't very objective, though, and not very communicable.

S--Yes, it is. It is to these art people; there is nothing at all mysterious about it. That is what they live with; it is their reality.

Q--What about the rest of us?

C--I would like to comment because I agree entirely with this presentation. It seems to me that the depreciation of art is the means by which a great many people, including many scientists (and I think the reverse happens with most artists), exclude a good deal of vital experience. We tend to say that art has no use, but I believe we mean that it has no practical applications of the kind that we associate with the developments of applied science. But art has the use that it configurates our life, it allows us to order our inmost being -- and this is what you are saying, isn't it?

S--In these research papers I have tried to point out that I have lived between two pendulums. I live between friends who are artists and friends who are model builders in the social sciences and it has taken me several years to come to the place where I have been able to verbalize about it. I do not feel split despite the poles; somewhere there is a basic unity; it is this unity I'm trying to verbalize now.

RECENT CREATIVITY STUDIES AT EDUCATIONAL TESTING SERVICE

John R. Hills
Educational Testing Service

S--Since the purpose of this conference is to discuss current research and ideas concerning the identification of creative scientific talent, I shall try to bring you up to date on the relevant things that have been happening at Educational Testing Service. ETS is not now making any direct attack on the problem of identifying creative scientific talent. However, a number of things have been done, are currently under way, or are being planned, which are related to the problem.

Three studies in which I have been involved were mentioned in the 1955 Utah conference on the Identification of Creative Scientific Talent. Guilford discussed the study of the relationship between certain factor-analyzed abilities and success in college mathematics. That study is reviewed in the report of the 1955 meetings and is available as Report #15 from Guilford's project, and parts of it will appear as a validity study in the Winter, 1957, issue of Educational and Psychological Measurement, so I will not take any more time for it now.

At the last meeting, Saunders of ETS discussed at length our research on predicting the success and placement of graduate engineers. Although I was deeply involved for some time with that study, at the conclusion of the phrase described by Saunders, I turned to other interests -- except for one small segment of those data. Saunders briefly mentioned the fact that we included a Controlled Association test in our battery and found that remote (uncommon) responses, which we expected to measure originality, were correlated with none of our other variables; whereas the number of obvious, common responses turned out to be the best single predictor of engineers' success, independent of function or types of work (e.g., research, supervision, scales, etc.), in the whole study. I followed up on this test to see whether the degree of relationship of the common-response score with the success criterion depended on how stringently one defined "common." Common responses had been defined as the smallest set of response words in pretest data which would account for 50% of all the responses given to each stimulus word by the pretest group. In the follow-up I used additional keys which defined common as 20%, 35%, and 70% as well as the 50% and 100% keys used before.

It turned out that the highest uncorrected validity for the common-response score on either the initial sample of 399 cases or the cross-validation sample of 287 cases was about .17. Clearly no single test of our entire battery of over 50 scores was doing a very good job of predicting success, even though the relationship between the common-response score and that criterion was statistically significant. When one corrects the correlations of the various common-response keys for attenuation due to score unreliability, it appears as though the most stringent definition of common, the 20% key, may be the best one, and a maximum correlation of this variable with our success criterion would be in the neighborhood of .20. However, such a conclusion rests on very large corrections for attenuation. The principal relevance of all of this to identification of creative scientific talent is that if anything predicted success, it was not the "uncommon" (original) responses but the common ones, and there is just a slight indication that common responses are most predictive of success for the most technical engineering jobs. There was also a hint that the success of research and production engineers was better predicted by this than were the sales and supervisory types.

C--This suggests to me that maybe the most common responses are measuring not associational fluency, but the factor of eduction of correlates, which might be responsible for your validity.

S--I think it is related to Calvin Taylor's hypothesis presented earlier that if this test predicts for scientists at all, it may be their willingness to use first-order constructs, very similar or very common types of words.

Q--Wouldn't the ones that are less remote resemble the stimulus word more than the other ones do?

S--Yes. In case you do not recall this test, the given words were words like mad or little and the instructions were: "Write as many similar words as you can to each of the given words." For the word little, small would be a very common response. The criterion was ratings of success on the job. In some of the five companies we used the companies' systematic ratings, but in the other companies where such ratings were not available, we provided a rank order form for rating engineers on overall competence.

Q--Could this be a kind of convergence measure?

C--Yes, the eduction of correlates is convergent.

C--Also maybe a measure of conventionality, then. Maybe those with wide-ranging associations, by definition, do not think like everybody else and do not get along with everybody else.

S--We have a lot of hypotheses for this.

Q--The test really asks for convergent thinking, doesn't it? If you instructed the subjects to think of the most uncommon association which you can justify to these given words, then you would have a different set which would ask for divergent thinking.

S--There are many ramifications you can follow from this, but I'm not very encouraged about it with a correlation of .17.

Q--Are you saying that none of these 50 scores had any sizable correlation with your criterion and this was your best one?

S--Yes.

C--This might be a chance finding.

S--It could be, or the criterion might not have been very good. Now to turn to other completed or nearly completed work. Barbara Wand, who until recently was on our staff, is winding up a study of problem-solving flexibility -- a topic clearly relevant to creative scientific endeavor. Mrs. Wand is interested in measures of flexibility other than the kind of flexibility involved in being able to adapt easily to new rules of procedure. She set out to develop experimental, group measures of flexibility and to ascertain whether these tests had a component of agreement among themselves other than what could be accounted for by measures of ability or measures of other previously-identified flexibility factors. If so, she wanted to know how this variance might relate to personality measures.

Many of the tests she devised were patterned to be like standard ability measures except for the introduction of features which would require flexibility for a superior performance. (She was intrigued at the time with the idea that in a standard vocabulary test the items might be ordered in such a way that you would introduce a set which would make the test more easy or more difficult for people. By item arrangement she suspected you could make flexibility either an asset or a handicap.)

For instance, as a reference measure of numerical facility she used a standard test of arithmetic computation (adding, subtracting, dividing, fractions, decimals). To introduce flexibility, she posed problems such as: add 76 + 77 + 78 + 79 + 21 + 22 + 23 + 24. She examined the subjects' scratch paper to make more certain of whether an examinee used the notion that since 76 + 24 = 100, 77 + 23 = 100, etc., the sum is easily found to be 400.

As a reference measure for vocabulary she used the School and College Ability Tests (SCAT) vocabulary test. In her new test which introduced flexibility she gave a paragraph which included a number of words that are used in widely different senses, e.g., a "bank" may be a place where one saves money or it may be the side of a creek. In the paragraph the word "bank" would be used in one sense, e.g., a grassy bank of a river. In questions about the paragraph, subjects were asked to pick out from the paragraph words that had the alternative meaning. In the case of the word "bank," they would be asked to find in the paragraph the word that meant an institution devoted to having custody of, lending, and issuing money. She also developed spatial tests along the same lines.

Mrs. Wand also used flexibility tests that were not patterned after any particular reference test. For instance, one test requires the subject to perform activities such as the following:

Think of one word related to both of these words:

1. Coal Possess M______________.

2. Bellows Strike B______________.

In another test she posed this problem: A country grocer dreamed one night that the items on the shelves of his store were discussing the qualities one needs to get ahead in the world. "One needs push," said the button. The pencil remarked that one must never be led. Said the window, "Take pains." After a few such examples, the subjects were to add as many additional remarks of this type as they could.

To provide more complete coverage of variables which might be related to these new flexibility tests, Mrs. Wand included a number of additional reference measures. These covered Thurstone's factors of flexibility and speed of closure, Guilford's adaptive flexibility, Schier and Ferguson's cognitive rigidity, and spatial factors. Also included were a questionnaire measuring a number of personality factors, an interest test, a sentence-completion test, and a questionnaire about spare-time activities.

Her results showed that indeed she had developed group tests with variance components which were to a large extent separate from reference ability and flexibility measures. These experimental tests did not tend to agree among themselves, however. Further, when she compared the correlations between her flexibility tests and the personality variables with the correlations between similar ability tests and the personality variables (in order to see if there were relationships between the flexibility components alone and personality traits), a strange thing happened. Very few significant differences were found. Also, flexibility and personality measures tended to be totally unrelated to each other. Further, whenever a correlation between a personality trait and flexibility was significantly different from the correlation between that personality trait and the relevant ability measure, it turned out that the ability measure was correlated with personality but the flexibility measure was not. (By way of illustration, if we had a personality trait p, an ability reference measure a, and a flexibility test, f_a, patterned after ability measure a, then we might have $r_{pf_a} = 0$, and $r_{pa} > r_{pf_a}$.) As far as I know, Mrs. Wand does not yet have an explanation for this finding that satisfies her.

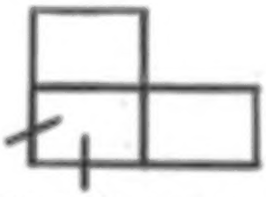
Q--Did she find any evidence of a redefinition factor? They seem to be more redefinition than flexibility in nature.

S--She didn't factor her data nor did she have any redefinition-reference test, so I don't think she knows.

Q--Were they items or scores in personality?

S--They were scores from the Personality Research Inventory. She had scores for factors called self insight, anxiety, self acceptance, tolerance of frustration, tolerance of ambiguity, compulsiveness, social conformity in handling aggression, and liking to think analytically. I believe she compared all of these with the ability and her flexibility tests.

Another study of flexibility, in process, has as its impetus the notion expressed by legal educators that many entering law students conceive of law as based on airtight logic with clear bases for decisions always available. The law professors wonder if, since law is not nearly so clear-cut as that, many students drop out or fail due to an inability to be flexible, to work with ambiguities, and so on. This situation provided the possibility of administering to a large group of entering law students (about 500 from eight different schools) a variety of measures of things like "flexibility" in order to see how they interrelate and which, if any, are related to such things as law school grades, choice of field of law, etc. We have included two of Guilford's tests from his work on creativity: Match Problems measuring adaptive flexibility, and Brick Uses measuring spontaneous flexibility. Match Problems presents the subjects with drawings of groups of matches laid out to form patterns of squares or triangles. The task is to take away (cross out) a certain number of matches so that a certain number of squares or triangles remain. For example, take only two matches and leave two squares in the diagram below.



Brick Uses asks the subject simply to list as many uses as he can think of for a brick, e.g., to build a house. This test is scored for our purposes by counting the number of times a subject changes his "set." One set might be uses which involve building, e.g., build a house, build a terrace, build a wall, etc. Another might involve throwing a brick, e.g., to throw at a cat, to throw at cans, etc. A third set might be related to the brick's porosity, e.g., to soak with kerosene and take to the beach for a fire, to make walls for a cesspool, to make an irrigation channel, etc. From pretests a comprehensive list of common categories has been made up, and a point is given each time the examinee changes from one category to another. Some subjects tend to exhaust a category before shifting; others flit back and forth. The "flitters" would get a higher score on spontaneous flexibility.

We have also included two tests developed by Norman Frederiksen at ETS for measuring report-writing ability. One is called Recognizing Ambiguities; the other is Evaluation of Revisions. Both require subjects to discriminate between ambiguous and unambiguous verbal statements. For instance, in Recognizing Ambiguities an item might read:

> The plot is pure farce, involving a phony British nobleman's quest for the hand of an American heiress, a social climbing American mother, and a visiting English lady named Mrs. Wollope.

The subject should check on his answer sheet that this is ambiguous. In Evaluation of Revisions the subject should indicate on his answer sheet that the following two sentences have the same implications.

The General Services Administration, the Government housekeeping agency, declared that Federal "gobbledegook" was not only confusing but also costly.	The use of Federal "gobbledegook" not only is confusing but also costly, according to the General Services Administration, the Government housekeeping agency.

It has turned out that these report-writing ability tests are subject to a rather strong response set which we call "criticalness." Some respondents seem to have a much lower threshold for ambiguity. Others tend to see everything as very clear and precise. These response-set scores will be our main interest in studying these tests in this battery. We think they may be related somehow to the kind of flexibility under consideration. They do not seem to me to be very much like the kind of response sets which Cal Taylor is studying, so maybe, together, we are covering many response sets.

In addition to the tests I have just described, we also have included two questionnaires which are supposed to be improvements on the California F scale measure of Authoritarianism. Lack of flexibility plays an important part in the thinking about this syndrome. The authoritarian, or as Bloom and his colleagues have called him, the stereopath, among other things is supposed to be rigid in set and outlook, inaccessible to new experience, resistant to departure from tradition, rigid, and compulsive. According to these authors, the authoritarian person might be expected to have difficulty in tasks involving such things as ambiguity and departure from conventional standards.

The "improved" measures of authoritarianism we have used are a short form of the "Inventory of Beliefs," a measure which Stern, Stein, and Bloom discuss in their book on assessment, and the Dogmatism Scale, Rokeach's improvement over the F scale. The Inventory of Beliefs items were obtained, as I understand it, by asking faculty members of a wide variety of institutions to submit clichés, pseudo-rational statements, and inappropriate generalizations to the item pool. Presumably the authoritarian will agree with such statements more often than other people will. Although the item content and style is very similar to the F scale of Adorno et al., the items in the Inventory of Beliefs sample a much broader range of attitudes than those covered in the Fascism, Ethnocentrism, and Political-Economic Conservatism scales. Stern, Stein, and Bloom believe that this inventory represents the overlap between the three California scales.

Rokeach has pointed out the fact that the work of Adorno et al., on authoritarianism and intolerance was started under conditions which led to the equating of authoritarianism with Fascism. Hence their measure was called the "F" scale. However, authoritarianism is present among radicals, liberals, conservatives, reactionaries, and middle-of-the-roaders and it can be found among scientists, artists, philosophers, and others where fascism and ethnocentrism may not be issues. Thus Rokeach's concept of Dogmatism and his measure of it try to account for a much wider range of phenomena than the "right" authoritarianism studied by Adorno et al. Presumably the person who scores high on the Dogmatism scale is also inflexible in a sense which may interest us.

C--We found the results for the F scale to have little relation to the claimed trait of authoritarianism. If anything, the results were slightly in the other direction. Furthermore, it is so highly correlated (negatively) with measures of verbal comprehension that we are dubious that you can get much else. We tried it on about 8 samples and it correlated uniformly high, between -.65 and -.70, with verbal comprehension measures.

C--The Inventory of Beliefs correlates about .29 with the Linguistics score on the A.C.E. examination. All our studies were made by equating students on aptitude and then trying to discriminate between them in other ways.

Q--The adaptive flexibility factor is in the structural column and I think it may not correlate with other verbal flexibility. Did you correlate tests of originality with the F scale?

S--No, not in this study. All of these "flexibility" measures, Match Problems, Brick Uses, Recognizing Ambiguities, Evaluation of Revisions, the Inventory of Beliefs, and Rokeach's Dogmatism Scale, together with a number of other test variables, have been given to a good many law students. We are now starting on the scoring and analysis. This fall and winter we hope to finish scoring and get further data analysis under way. The results should give us some more of the information necessary for an understanding of the ramifications of the concept of flexibility. I believe it will be one of the few times that Guilford's tests have been studied in relation to the authoritarian personality syndrome.

On a more or less informal basis so far, Frederiksen is exploring the possibility of measuring something like originality, or perhaps some other trait related to creative scientific talent, in a test which we refer to as the Hypotheses test. This might be of interest especially in connection with Flanagan's Test of Ingenuity. The essence of the hypothesis test is that a set of data is provided the examinee, e.g., a table or graph of the distribution of assets of U. S. Life Insurance companies during a particular period of time. You will see what I mean on Figure 1 (at the end of this report). Some finding or conclusion evident in the graph is drawn, e.g., insurance companies are investing proportionately more in industry and building since World War II. The examinee's task is to list as many hypotheses as he can that might explain or account for this finding. Then he is asked to list the additional information he would need to decide whether each hypothesis was the correct explanation or whether the finding is true. Figure 1 includes sample responses of these kinds. Certainly this task appears to be similar to a crucial part of the scientist's tasks.

The test can be scored in many ways. One which is now being studied is scoring in terms of hypotheses which seem "good" to us (i.e., not nonsense) but which have never or rarely ever occurred previously among similar examinees. A self scoring idea might be interesting to those who tangle with free-response scoring. On this test we might have a list of previously found common responses which we pass out to subjects after they have completed their responses. We ask each of them to put a number beside a given response that is like one he produced. Then we have him list at the end, all of his responses that are not like any of those in the set that we provided for him. However, techniques are needed for checking on the examinees; they do not always resist recording one of the good hypotheses that you have given them as though it were one that they had thought of.

Q--You've never played with giving them a choice as to whether they ask for more information or draw their hypotheses? That might reveal a response set to see whether they feel they are ready or whether they must have more information before listing hypotheses.

S--So far we haven't tried that. They can write down hypotheses and also write down information needed at the same time.

Q--Isn't it possible in terms of some of the things said this morning about parsimony and centrality that one hypothesis might be better than another and if that one occurs first, the person will have difficulty writing more?

S--Yes, he would be penalized by the present scoring system, but there's no reason why a quality scoring system could not be used also, if one is desired. Recently one subject came up with three entirely new, good hypotheses, an event which is so unusual that

Frederiksen, who is Director of our Research Division, remarked that without regard to other qualifications, he would like to hire the man. This test is still in its infancy, however, so I can only report enthusiasm -- no concrete results.

In our Test Development Division, two studies related to creativity, though not specifically to scientific creativity, are being conducted. The farthest along is a study, under the direction of Dr. Robert Solomon, aimed at improving the prediction of success of architecture students. Previous studies had indicated that over-all grade averages in the architectural program could be moderately well predicted by verbal and mathematical scores on traditional tests and by high school rank in class, but that grades in design courses could not be predicted by these measures. It was hoped that supplementary tests could be developed which would improve prediction. A large number of architecture students from 12 schools took a six-hour battery of tests in our experiment. Included were measures of reasoning, spatial abilities, interests, and knowledge of sociology.

Of interest to us here are the tests aimed at measuring productivity of ideas. A number of tests of this sort were included. One was called "Incorporated Lines." It requires the subject to draw as many different figures as he can that incorporate two given simple lines.

Q--That has been called the pictorial fluency factor in an Australian study. Does this description make sense?

S--Yes, they were thinking of productivity of ideas in architecture students. Another test is the "Layout Test." This requires the student to create a "best" office layout on the basis of conflicting criteria. It is presumed that people who make more layouts will have a greater chance to score high. A third test is called the "Space Fitting Test." The task is to produce as many different arrangements as possible for fitting a small number of blocks into a given space. A similar test in only two dimensions is the "Dot Pattern Test." It requires one to find as many different ways as possible for drawing two given lines in a given pattern of dots. These tests will be scored, criterion data will be collected, and the interrelationships will be examined during the next year or two.

Q--Is there any tendency in the Dot Pattern Test for the dots to be distributed in accordance with propensities of personality? I tried a test like this in my course on the creative process and found that the students' responses fell into three very different patterns when they were told to configurate after seeing a flash card.

S--These data have not yet been analyzed. They may not be planning to look for such things, so I'll mention it to them.

C--It might be good to put in a question mark about the assumption in the previous procedure, namely, that the more produced, the more likely they are to produce a good one. We have one small study in which we find no relation whatsoever between the solution of the problem and the number of hypotheses produced per unit of time.

S--The best subject might be one who doesn't put any ideas down and waste time that way until he has thought it all out.

C--He just thinks for the right one. We had the other assumption earlier until we got as close to a random relation as you can get.

S--The last study I will mention today is one that is still suffering birth pangs. Dr. Dora Damrin is starting to plan research into the methods of problem-solving used by people in the field of medicine. By use of the "Tab Test" format, she hopes to find out how hypotheses are formed and broken, what false leads are taken, and how one gets back on the right track, in the context of medical diagnoses. In case some of you are not familiar with the Tab Test idea, it is a development that grew out of attempts to study proficiency of electronics repairmen in the Air Force. In many military electronics installations the repairman's problem is to ascertain which of a series of "black boxes" is malfunctioning and producing a given symptom. He then unplugs that box, replaces it with a new one, and turns the old one in for salvage. In this situation you have the symptom -- which is usually rather vague. You have the checks and tests that can be made -- such as voltage readings, etc., at various points in the gear, and you have various units that can be replaced. The Tab Test is organized along similar lines. First, a symptom is given -- maybe a radar screen is blanked out. Along one side of a piece of paper, the subject is presented with a list of possible checks that can be made on the gear. Along the other side, covered by opaque removable pieces of paper called "tabs," are written the results of each of these checks. For example, on the left a check might be: Adjust the servo. On the right covered by a tab would be: With proper adjustment, all the trouble symptoms remain. If the subject wants to check the servo he removes the tab (placing it on a spindle). He can read the result of his check.

The subject also has a list of units he can remove and replace. Covered by the tab for each of these units is the word "No" if it is a wrong unit, and "Yes" if it is the single right one. An examinee can be scored for various things such as whether he finds the right unit, how many wrong ones he replaces before getting to the right one, how many checks he makes, etc.

It is easy to see how the same sort of device could be developed for medical diagnoses where there is a symptom, a number of checks, and, somewhere, a malfunctioning unit or two. The test can be modified to take advantage of Cal's idea that some people get creative when stuck. Dr. Damrin is currently thinking of rearranging the standard Tab Test procedure to employ an index through which the subjects get their information. The details of the entire study remain to be developed. Dr. Damrin hopes to have it under way in 1958 or 1959.

C--you're aware of the similar studies at the University of Chicago and at UCLA. Tab tests of medical cases as well as pure situations in which you turn lights on and off in a particular box have been used.

Q--I have a burning question. I think that there has been a lot of fruitless research in creativity and I think it is quite appropriate for us to get "Irish correlations" at this stage of knowledge, but it seems to me that we must try to understand why this research did not work, so that we may improve on these designs. For example, hearing reports on these first two studies at least -- I realize that you were not the principal investigator and may not know the details -- it is somewhat frustrating to be given a set of Irish correlations, as in the first reported study with over 50 measures and none correlated significantly at the level you set, and then to have it dropped at that point. I do not think that anybody has to get high correlations, but I think we do have to find some way of understanding why the thing isn't working out. Is it that we have not identified what we are after? Is it that our criteria are not very clear, not very good, or that we are throwing a lot of different kinds of things under a single name? Is it that the methods of analysis we are using, the statistical methods, do not reveal the kind of thing that may be even in the data themselves? I realize that there is no simple answer to this, but somehow or other I think that this is a responsibility that we all do have. Maybe we might write a longer report than perhaps the report itself on why it did not work or how we can account for the results.

C--If an agency as large and reputable as ETS works through this and finds nothing there, maybe the problem of creativity is an insurmountable problem, so that we just have to give it up for quite a while; maybe we are all going down the primrose path and there is nothing there after all; or is it possible that there is something about these studies that may help us to understand how to design studies in the future?

S--With regard to that particular study we have heard things at this conference that would help explain the results. I believe that it was Calvin Taylor who reported the use of the customary official ratings as criteria of scientific or research competence. As I recall, very little relationship was found between such criteria and the predictors. But Don Taylor found that ratings of merit obtained from the normal administrative procedures were unsatisfactory. He obtained special ratings for research purposes and was much more successful. In the study which I reported, some companies had administrative merit ratings, others had special research ratings, and these were all put together as a single criterion to be predicted. Perhaps that alone accounts for the Irish results.

C--I would like to understand it. I would like to have the investigators attempt to explain what might have gone wrong and what are some of the ways that we might in our next efforts improve upon them. I think there is nothing wrong with our getting these Irish correlations. The question is, "What does it teach us?"

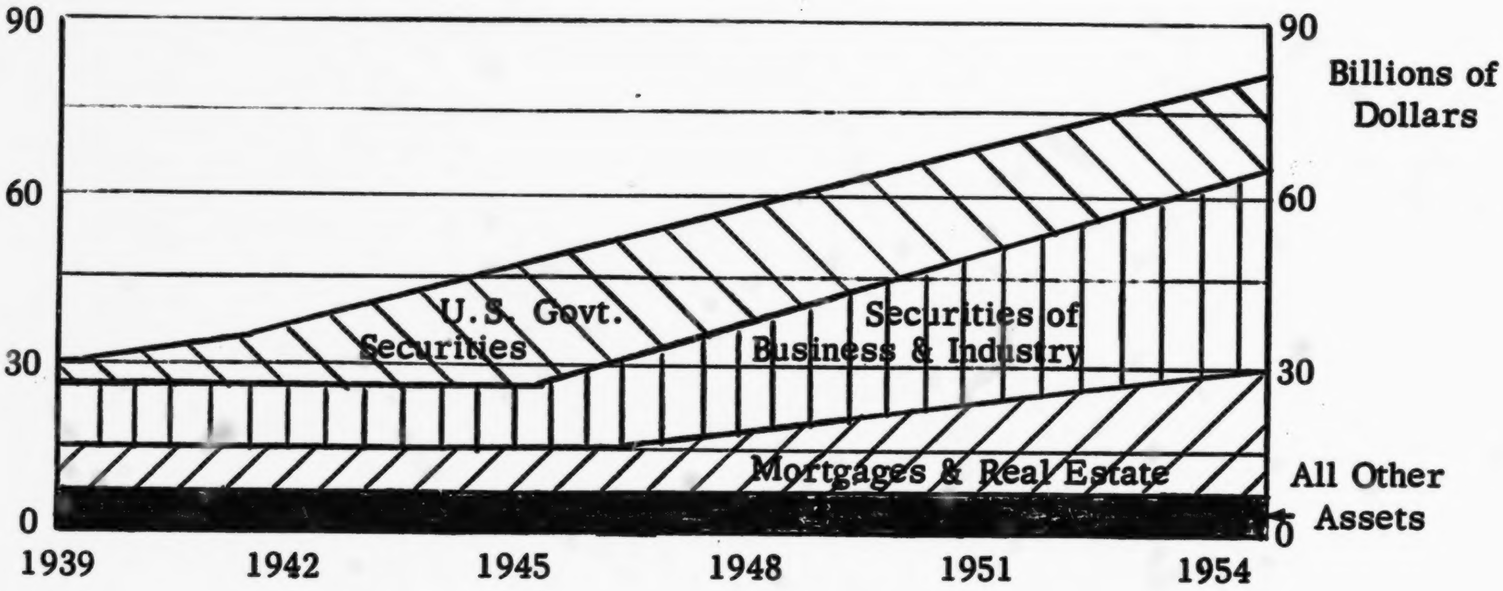
C--I don't agree with that. I think there is something wrong with getting them. I always feel that way when I get them.

C--The investigator is often too close to it, too, to arrive at the best answer as to what was wrong.

C--This may then suggest that conferences like this might spend a little time in going over some of the real bad ones and begin to ask why, not to condemn or praise, but to understand, so that we may improve upon them in the future.

S--I believe that now I have described the research at ETS which is related to creativity. As you can see, none of it is peculiarly aimed at identification of creative scientific talent. But I suspect that scientific creativeness is but little different from other kinds of creativeness except in the tools and materials which the creator employs. To the extent that our researchers achieve their own goals they should be found to contribute to the solution of the problem that brings us together here.

Figure 1. Formulating Hypotheses



From Life Insurance Fact Book, 1955, p. 60. Distribution of Assets of U. S Life Insurance Companies.

Finding: The proportion of funds supplied by insurance companies for industry and for housing has increased since World War II.

Directions

Each problem in this test is based on data obtained from an actual study. For each problem you must:

1. Write short statements of hypotheses (possible explanations) which you think might account for, or help to account for, the finding. You will have 10 minutes to write as many as you can.

2. On the second page of the answer sheet you will be given an additional 10 minutes to write items of information which you would need to test your hypotheses or to judge more adequately the truth of the finding.

Hypotheses: (Examples of answers)

1. Insurance companies have more money to invest since World War II.
2. Housing and industry investments pay a greater return than others.
3. With inflation it takes more money to be equal to pre-World War II investments.

Needed Information: (Examples of answers)

1. The decrease in purchasing power of the dollar during this period.
2. The regulations concerning the VA and FHA loans.
3. The method of collecting the data.

WORKING PROCEDURES OF CREATIVE SCIENTISTS

Myron S. Allen
Long Beach City College

S--My approach to the highly critical problem of the identification of creative scientific talent is from the point of view of a long time instructor of college physics, who can no longer endure the restrictions of the academic rut that, by and large, is responsible for such an inadequate job in the identification and development of creative talent in scientists, engineers, doctors, and others who hold the future of this country in their hands.

Prior to my work in physics, I graduated from a well-known eastern college of engineering, and in recent years have found myself increasingly engaged in scientific consultant activities of one sort or another. I will discuss from the viewpoints of a teacher, physicist, and consultant, what I feel are some of the present weaknesses in the teaching of science. I will also present a brief outline of the sabbatical program on which I am now starting and how it is expected to ascertain at least some of the changes that should be made in the teaching of future scientists.

I feel very fortunate indeed, and grateful, for the opportunity of discussing these vital matters with the members of this conference, and know that the comments and suggestions offered will make far more likely my achievement of significant and worthwhile results.

Two rather terrifying weaknesses standing out in the current crop of science students are an insistence on security and a rabid dislike for thinking, particularly with respect to "open-ended" problems -- that is, problems which are unique to the student and which may have several possible solutions, one of which must be selected on the basis of specifications that have been established.

I have just returned from a visit to the General Electric Company at Schenectady, New York, where I made an intensive, though brief, study of their advanced program of study for engineers and scientists. Even though the General Electric recruiters had used the utmost care in the selection of the engineering and science graduates who would be best able to fill the needs of the company, three or more years of additional training are needed to prepare these men for their jobs as creative engineers and creative scientists.

There were two characteristics in particular which the G. E. training officers found lacking in the technical graduates who came to the company. One was the inability of a person who had been trained in one field, such as electric engineering, to utilize the basic work in another field. For example, the mechanical problem of vibration is one that in many ways limits the electrical design of an armature and which the electrical engineer would normally know little or nothing about. The other glaring weakness was the lack of ability to handle open-ended problems in a creative manner.

I talked with the dean of a school of engineering recently about creativity in its limited sense of originality, ideational fluency, flexibility, etc. His position was that this was not an essential characteristic for an engineer to have. "If a bridge has to be built from here to there," he stated, "all that is necessary is to select one standard design for a bridge from the six or eight available, and then put the pieces together."

The fact that his pet designs had not been originated all in one day, that new needs might necessitate an entirely new type of design which new materials now made possible, apparently had not occurred to him. The dean also expressed a strong desire for the security accruing from the exclusive use of approved, generally accepted practices -- which would protect him from censure or liability whenever he followed them even if failure still resulted from causes not due to some error on his part.

About one year ago, I was called in on a job in Los Angeles that clearly illustrates both the difficulty a fixed-idea engineer can get into when he does leave his familiar rut, and the reason why he gets into trouble. It was in the month of January that I entered the picture. The outside temperature reading was 68 degrees Fahrenheit, but with all available air-conditioning equipment in full operation, the inside temperature reached 90 degrees in this curtain-wall constructed building.

Frank Lloyd Wright -- undoubtedly one of the world's most creative architects -- had established a fundamentally new design for office building construction. Instead of using a great number of bearing walls to hold up the roof, Wright erected a central column and hung the framework of the building thereon, as the branches of a tree are held up by the trunk. With the same expenditure of materials and labor he was able to provide the owner with up to 25% more office space. Such an attractive increase in revenue could not be ignored, and architects and engineers were forced to use this so-called curtain-wall construction, even though it was beyond their experience.

In the building in question, the previous attempt to handle the solar radiation problem arising from curtain-wall construction with its thin walls, had failed miserably. First, heat absorbing glass was used with complete neglect of the corollary idea that any good absorber is also a good radiator; this resulted in the 90 degree office temperatures. Next, somebody remembered that double windows saved fuel in the colder areas of the country by reducing heat flow from the rooms. Equipping a test room with double glass resulted in an even hotter room. In this case, the simple fact that heat always flows from a hotter to a colder place was completely neglected. When the problem was presented to my freshman physics class, one clear-thinking youngster commented, "It seems to me that it would have been much better to have bored some holes in the original window so as to let out some of the unwanted heat."

Our own recommendation was made because we recognized two very well known physical principles that had been overlooked by the architect and the air-conditioner engineer. One, that if but one-quarter of an inch of vacuum would prevent the loss of heat from coffee for several days, then the 93,000,000 miles of absolute vacuum through which the energy from the sun has to pass precludes any possibility that this energy be in the form of heat. Two, that the radiations from the sun are electromagnetic in nature and can be reflected or otherwise controlled only by the use of a metal reflector. This suggested a reasonable solution of adding a metal louvered screen and another piece of glass, making a metal sandwich which would reflect the electromagnetic waves. The air-conditioning load was reduced by 64% and satisfactory room temperatures were easily maintained with the existing installation of cooling equipment.

While talent, or ability, is absolutely essential, it is performance that is paid for. Between ability and performance are a pair of intimately related factors of motivation and climate. These are being neglected by at least some of the major engineering schools through their insistence that lower division physics courses shall remain "pure" science. By this they mean that the use of applications of the principles of physics shall be held down to a minimum, and that problems assigned shall have very specific answers. I am quite sure that this philosophy of engineering education underlies the weaknesses earlier referred to with regard to the handling of ideas and the solution of open-ended problems.

Operating department heads at the General Electric Company come into the various creative engineering classes and say, in effect, here is a problem confronting us that so far we have been unable to solve. We would very much appreciate your help in finding a number of possible solutions. The group of students who accept this problem know in advance that there is no formula available to give them a direct solution. It will be necessary for them to accumulate and/or create ideas from which solutions may evolve.

This type of problem-solving may be gently and unobstrusively introduced into any science course, even where a fixed curriculum has been provided. Eventually, the bondage of a set pattern of subject sequence will be broken. Problem selection and sequence closely allied to the needs and interests of the class will determine the curriculum. So far as I know, and I would like to be corrected if I am wrong, there has never been any good reason advanced for teaching physics one package at a time -- mechanics, heat, sound, light, electricity, electronics, atomic structure, and nucleonics, in that order. Neither our interests nor the utilization of scientific knowledge develops in this way -- so why must our physics courses be so organized?

If a man were to be found walking around in a food fair -- where an unlimited amount of free samples is available -- crying out that he was starving to death, someone would soon ask him why he did not eat. In a similar vein, when there is so much talk about attracting good students to science classes, and when the need for creative scientists is so acute, why is an academic climate insisted upon in which creative thinking is inhibited, and in which a man is made to feel so uncomfortable if he exhibits originality?

During the past year I have done some experimentation with class sessions in which a problem was presented -- sometimes by myself, and sometimes by one of the students -- on which group ideation was then requested. We strictly enforced the rule that there be absolutely no adverse criticism while the group ideation process was being carried on. The class was strongly urged to express any idea at all that occurred to them -- whether it seemed good, bad, incomplete, or seemingly irrelevant. It was found that after a considerable number of "surface" ideas had been expressed that intuitive ideas began to emerge from where ever they had been resting.

One girl brought in a problem of great concern to a business friend of her father with the request that the class practice group ideation on it -- to "brainstorm" it, using Alex Osborn's technics. The results were so acceptable, when received by the businessman in question, that he expended the sum of $8,000 to utilize the class suggestions in the solving of his problem.

At the beginning of the course I asked these same students to state their conception of a real scientist. Their group understanding was thrilling to behold. I then announced that as originality, flexibility of thought, the creation and modification of ideas, and the application of ideas to problems were prime characteristics of a scientist -- and as they were themselves science students -- I would expect these same characteristics to be manifest in the work of any student if he were to receive better than an average grade.

The class was given some specific suggestions relative to the demonstration of the creativity sought. The conception of simple inventions to care for some real or imaginary need was encouraged. To change the laboratory work from the usual cloistered, cookbook practice, the principles investigated in the laboratory were to be taken outside to industry and to the professions -- to see at first hand what their newly acquired knowledge was really good for. For example, in a class with many pre-medical and pre-dental students, we were talking about sound waves. I casually remarked that I had heard that dentists are now excavating teeth with sound waves, that it sounded kind of interesting, and I wondered if there was anything to it. After completing their laboratory experiment on sound waves those who were interested went outside of the laboratory and had a real interesting time visiting dentists using sonic drills, thereby gaining a new perspective of their classwork. These simple modifications of an otherwise standard course resulted in the most creative work and the best sense of achievement on the part of both the students and their instructor that I have found in any class during 30 years of physics teaching.

I would now like to present some of the major aspects of my intended research activities for the coming year. So far as possible I have freed myself from all other demands on my time, because I feel that the identification and the development of creative scientific talent is as worthy an activity as could be found. I will be in close association with J. P. Guilford at the University of Southern California. As one phase of my work I will try to bring together the findings of John C. Flanagan and his associates of the American Institute of Research, and the factor studies of Guilford -- particularly with respect to creativity or creative talent. It is expected that this analysis and synthesis will yield interesting and valuable results. As both the Flanagan and the Guilford studies are such extensive and well planned investigations, it seems quite likely that an element of creativity found in one series of studies and not in the other would indicate either an error or an omission by one of the investigators. As you know, Flanagan's investigators, using his "critical incident" technic, did not consult directly with the creative scientists themselves, just with someone who knew them. His procedure was to ask who is one of the most creative persons you know? What is he like? What does he do? The same series of questions were then asked concerning the least creative person known.

The Critical Behaviors Checklist, as presented in the October 1955 Bulletin of the American Institute of Research, "Procedures for the Evaluation of Job Performance in Scientific Research," groups the evaluative items into six categories: Area I, Formulating Problems and Hypotheses; Area II, Planning and Designing the Investigation; Area III, Conducting the Investigation; Area IV, Interpreting Test Results; Area V, Preparing Reports; Area VI, Accepting Organizational and Personal Responsibilities.

A very brief preliminary study has shown many points of contact between the Guilford and the Flanagan studies. For example, the Guilford factor of numerical facility seems to be inherent in the Flanagan Area IV, Interpreting Test Results. Again the Guilford factor of perceptual foresight would appear to be an aspect of Area IV, Formulating Problems and Hypotheses.

During the past year through my reserve relationship with the Office of Naval Research, I have been in association with many highly creative scientists participating in the work of the International Geophysical Year 1957 - 1958. In my own project, this coming year, I am to follow the plan of conducting a personal interview with each creative person being studied. I am taking this time-consuming approach because in no other way can I acquire the bits of information that will give me an appreciation of the "climate" in which the scientists, or other creative persons grew up. As a simple illustration of the significance of "climate" on the identification and the development of creativity, I would like to ask for a show of hands to find out how many of the persons in this room have ever had chores to do on a farm or have lived in a small town. This kind of response -- two-thirds or better -- is a typical one, as supported by "Starred Men of Science." There has been something in farm and small-town life that has stimulated creative expression. It is the responsibility of education to put into its curricula substitute experiences that will cause a reversal of the current trend toward security-first-let-somebody-else-do-the-thinking. The student who has learned to appreciate the thrill of some intellectual achievement is a real rarity. Stability is being replaced by tranquility pills. As schools establish curricula that motivate creativity and environments that stimulate creative expression, then will the American people reverse their trend and again become stronger -- instead of progressively weaker -- in so many of the essential aspects of life. We will once again read original documents and conduct our own research -- instead of depending on the Reader's Digest, and Kiplinger's Letters to do our thinking for us.

So far as time permits, in addition to interviewing scientists, I am to interview a wide range of persons who have demonstrated creative ability. These might be writers, teachers, advertising consultants, inventors, engineers, lawyers, business executives, artists, musicians, and so forth. Some of these interviews will be individual, and some will use the group ideation or "brainstorm" technic.

What I expect to come up with by this prospecting is a large number of relatively well proven ideas on creativity -- its identification, release, stimulation, and application to industry, education, and invention. These ideas should be of value in the development of better methods of problem-solving, in the training of military and civilian personnel, and in the setting up of additional hypotheses for further psychological research relative to creativity.

The selection of personnel to be interviewed will involve the finding of people who are recognized as being creative on a high level. When someone is recommended to me I shall ask for some concrete evidence in terms of actual creative achievements. Typical creative performance might be expressed in original patents, new processes, the quantity of evaluated writing done, and by many other technics.

My plans are still in a very fluid state, and any suggestions, comments, or questions will be deeply appreciated. When a piece of research has been completed and the final report has been released, suggestions are then given freely as to how the work might have been done in a much better way. Today, as I am setting out on my journey, I am asking you now for a few navigational aids, in order that my goals may be achieved.

Q--What sort of interview are you planning -- structured or semi-structured? What area of questions are you planning to cover?

S--The questions have not been worked out in detail. There will be some biographical questions.

Q--You are not working from any set hypothesis?

S--At the present time, no.

Q--Would you plan to as you move along on this?

S--Yes. I want to begin this freely. I am cognizant of many interview technics that have been used, but at the beginning I do not want to be limited. It is also well recognized that a stimulus that is somewhat vague will receive a deeper response. As many of the responses that I am hoping to get from the person I interview will not normally be from a conscious level, I am not starting out with a structured, or even with a semi-structured interview.

C--One of the problems is whether this is a personal quest in which your desire is to understand, to bring you up to an understanding of what things are, how they may be improved and so on, or whether it is an attempt to advance our understanding of this particular phenomena. I think that if it is a personal quest, then one moves off in almost any way he desires, and I suppose you will anyway, but if it is an attempt to add to our general understanding, then it seems to me that it must take into consideration what is already known, and there is a considerable amount of literature already on this, and that your hypotheses, your instruments, and your interviews must be something in advance over what has already taken place. This is a rather difficult criterion to meet.

S--That's true. I tentatively believe that my investigation as planned, directly into the mental processes of the scientist himself, is unique. I have not found any studies of this particular nature. Neither have I found any substantial research on the effects of climate or motivation on creativity.

C--I don't think that the studies we have done have aimed at the problem you are aiming at. Our critical requirements, our critical behaviors, were aimed at anything that a person does in a research laboratory. Some of the laboratories were not primarily for research, which would certainly influence the results obtained from our investigations. I think that studies such as you propose, aimed squarely at creativity, are very desirable ones and I don't think would duplicate anything we have done. I think that the point just raised is fundamental to your planning, namely, whether your study is exploratory and subjective in order to give you an insight into what the scientist is like (which you can then expound for general interest), or whether it is a data-gathering process where you use fairly objective and described technics to get information on specific aspects of the creative process. The second procedure would enable another person to go around asking similar questions and to be almost certain to come out with the same data, observations, and reports, which could then be tabulated. In other words, you get something which is objective and fairly public, or at least tends in that direction. I think that this is a question you will have to decide fairly early.

S--Are the two mutually exclusive?

C--On no, but it is very hard to get the latter kind of data if you are not setting out to get it.

Q--Couldn't he do first one and then the other?

C--Yes, that is the usual procedure with the subjective one first -- that is, do an exploratory study first to set up your hypotheses.

S--That is what I had in mind.

C--I still feel that you can have some fairly definite hypotheses in mind even in your preliminary interviews.

S--I agree with that very definitely.

C--You are in a more fortunate situation than I was when I set out to do this because there has been a great deal of work done. And you can start from a different level.

C--I thought that you were going to say something about the possibility of his starting with life history material mainly. If he taped his early interviews and took these to someone who was familiar with this sort of thing and formulated the best questions he could, he wouldn't get everything that he would later want, but if he continued then to get this information, plus additional things that cropped up which were unforeseen, at the end of the year he would have some of the public information mentioned in the earlier comment and he would also have some grist for an expansion of this. He would certainly have a lot of private experience. Of course, I like this sort of thing for the same reason that everybody else likes it. I like it because you can score it, because I think it gives a broad picture that makes possible a lot of hypotheses, and so on.

C--Perhaps one omission in your remarks was the mention of Anne Roe's extensive studies of interviews, which were much closer perhaps to what you will be doing than the critical incident studies which we have done.

C--I wonder if it wouldn't be well if you could know all the literature and all the approaches and then go out with the expectation of forming hypotheses that transcended any of these -- assuming this is not impossible.

S--I don't think that it would be advisable even if I could, because if I knew all that, I would be so hembound that I wouldn't have any originality of my own.

C--I wouldn't agree with that because you are bound by preconceptions anyway. We all are. The content of our minds -- the universe of thought we live in -- is a plexis of preconceptions anyway, so to have more ideas is not going to make it any worse. The problem still is to get away from them.

C--The bounds are tremendous as yet in this field. I don't think that anyone can now pin you down to a particularly small point which is the only thing we need to know. The bounds are so tremendous that one would hope that you would start by using what has already been done as a base. You correct things which you think are wrong in the past. You make an advance over things that have been done, and the like. And I think that what we would like to do if a conference like this meets two years from now, is to have you come out with a new advance other than further confirmation of some of the things we seem to know quite well.

C--Name one. (General laughter.)

C--I think that from what we have already gotten we could describe the task of problem orientation of the creative individual, and we would describe it in many different ways; but I think every time we approach this, we all come up with the same thing. Now you may be able to define it in a much more subtle way than we have, but I think that there are a number of things that are at present known.

S--One thing that disturbs me is that I can't see how I am going to get any correlations, Irish or any other kind, by the approaches I have suggested.

C--To take a different approach could even be healthy for the total research effort.

S--Well, that is encouraging.

C--I think the problem is that many of us over a period of years have conducted at least moderately large numbers of interviews on the basis of which we think we now have some insights but we can't publish them usually, at least we don't in terms of our usual practices. I spent one entire summer interviewing a large number of people, a study I did not report here, trying to get some insights of this sort. For me this was largely self-education, trying to get some notions which could then be put into some more testable forms so that if somebody else were to use the procedures that I used, they could hope to get somewhat the same answer. I think that what I am saying has already been said. Now if you are willing to settle at the end of the year for what I was willing to settle for at the end of the summer, namely a nice summer and some education, then I think you can afford to do that. If, on the other hand, you hope to come up with ideas which will be useful, not only for you but for other people, then you must somehow proceed so that you have evidence which they will find convincing, though not necessarily correlational -- not necessarily any particular kind, but some kind of hypotheses suitable for direct investigation. The field you propose to investigate is so enormous that if you set out to interview just one man, I should think that the interview could last for several days without being exhaustive.

C--I am interested in physics curricula and am intrigued by your suggestion that there is no good reason for the method of teaching physics, first by mechanics, and then heat, light, and sound. Are there any texts that attack the problem in the manner in which you indicate?

S--There was one attempt about 20 years ago, that I know of. But some 15 copies of the text were sold, with no adoptions, and I know of no more recent attempt.

C--It is actually being worked on now by a group that is called the Physical Science Study Committee. They already have a great deal of material all ready for tryouts in high schools that wish to cooperate in the preliminary studies. Several institutes are available for high school teachers who are interested in the work of improving high school physics teaching. I understand that Tufts University is working on a similar program in chemistry.

S--Are there any particular pitfalls of which one should be aware in a study of this type?

C--Certainly one of the elementary ones is a failure to watch yourself about people you interview whom you like personally in contrast to people whom you do not like.

C--I think that a thorough review of the literature would do you no particular damage and I would like to emphasize this. I do not think that it would take very long. We have been facing the same problem that you are, except that we are not going to travel and we have been working on a review of the literature for about two months. I think that if nothing else, such a review would tell you what not to do, as presented in some 50 to 100 articles. I think that this is invaluable. I think, too, that it may help you to shape up some hypotheses to narrow down the sorts of things that you particularly are interested in doing and that you feel more competent to do. I think that every investigator picks out a problem not just in terms of what he feels is important, but also in terms of what he is especially competent to do. I am sure that you as a physicist would be much more competent in areas that most of us would not be competent in, and I think it would serve a very real function.

CREATIVITY AND/OR SUCCESS
A Study in Value Conflict

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If the people on Mars are as curious about us as we are about them, then one of the things that might impress them is our tremendous concern with the problem of creativity. While in 1950 Guilford found that "less than two-tenths of one percent of the books and articles indexed in the Abstracts for approximately the past quarter century bear directly on this subject (creativity)," it is likely that if he continued to plot his curve for the past seven years, he would find a sharp increase in the slope. Governmental agencies, private foundations, as well as industry have been increasing their support of research in this area.

One might well inquire into the reasons for this concern with creativity and seek the roots of the social forces that have brought it about. It may be solely a reaction to the anti-intellectualism we experienced only a short while ago; it may stem from our desire to maintain the balance of world power in our favor; it may arise from the growing concern with mental health, etc. However, such inquiries are more appropriate for studies in the sociology of knowledge. We certainly do not expect to answer these questions today. All we can hope to accomplish today is to stimulate some broader thinking about the relationships between social factors and creativity in society generally through the exploration of data collected in a microsphere.

The material to be presented is a segment of a larger study that is devoted to an understanding of the social and psychological factors related to creativity in industrial researchers.[1] In the broader research, it is assumed that creativity is a process of hypothesis formation, hypothesis testing, and the communication of results. These results are accepted by others as useful, tenable, or satisfying at some point in time. This definition has been discussed more fully elsewhere (Stein, 1953). It underscores the point that a work must be accepted by significant others if it is to be regarded as creative. The fact that a work merely deviates from that which existed before does not mean that it is creative. The neologisms of the psychotic may be original, but they are not creative. The creative work "resonates" with needs and values of significant others in the environment. Creativity is therefore, for us, a phenomenon that must be understood within the social matrix in which it occurs.

In our study of industrial researchers, the companies in which the men are employed are regarded as sub-cultures or sub-systems of our broader culture. They may be characterized in terms of field forces and valences. The man, the individual

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[1] This study was supported by a grant-in-aid from the Committee on Personnel of the Industrial Research Institute. It is being continued with a grant from the Carnegie Corporation.

researcher, is conceptualized as a specific sub-field within this broader framework. The psychological characteristics of the individuals who are regarded as more and less creative in these sub-cultures will not be discussed today. They will be reported at some future date.

With this introduction in mind, let us turn to the problem that confronts us today.

Imagine a society in which there are only two values. One is to be successful and the other is to be creative.. With this fictitious, or not so fictitious, society in mind, several interesting questions arise.

1. To what extent are the skills and abilities necessary to attain and fulfill both these value orientations congruent? Do perceptions vary as a function of status level?

2. How do the constituent members of the society (researchers) compare with the culture bearers of the society (top level supervisors) in their perceptions of the skills and abilities necessary for success and the skills and abilities necessary for creativity?

3. How do more and less creative men compare with their top level supervisors in their perception of what makes for success and what should be rewarded for creativity? How do more and less creative men differ from each other?

The men studied in this investigation were all employed in the research divisions of three different companies. Although there are some differences between companies, our data were not sufficiently extensive to permit controlling for them. Hence, the men were treated as though they came from a single company. Seven supervisory status levels common to all three companies were discerned. There were seven men who were "top level" administrators; twelve men who made up the second echelon; and sixty-six men who came from five different supervisory levels within the research organization.[2] This last group of sixty-six was further sub-divided into one group of thirty-two "more" and thirty-four "less" creative men. The men were assigned to their respective groups by virtue of the ratings they received from their subordinates, peers, and superiors. All men were reliably rated. Superiors' ratings carried half the weight in the final rating and subordinates and peers made up the other half.

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[2] The number of men assigned to the different supervisory levels and the definitions of their levels are as follows:

Level 1 -- Not responsible for the work of anyone other than himself, or may share a technician or assistant with others. (N = 26).

Level 2 -- Has responsibility for the work of his own technician or one professional person (i.e., someone with a Bachelor's, Master's, or Doctor's degree (N = 15).

Level 3 -- Has responsibility for several professional people, all of whom work on pretty much the same project. Has administrative, as well as technical responsibility. (Most often called a "Group Leader") (N = 14).

Level 4 -- Has administrative responsibility for up to a dozen or more professional people, but may not supervise them all directly insofar as technical problems are concerned. Some of them can conduct their technical work independently of him or of each other, while others do work under his supervision. None of those he supervises are categorized as "3" for supervisory status; but all are categorized as "1" or "2", or are technicians (N = 6).

An analysis of the situations in which the researchers were employed revealed five roles: The scientific role, the professional role, the employee role, the social role, and the administrative role (Stein, 1958).

Statements of eleven skills and/or abilities related to these roles were constructed. A twelfth characteristic, autonomy, that might be found in the roles was also included. The statements are presented in Table 1. This table also contains an identifying code for each skill and ability that is used in the material to be presented and discussed later.

The statements were administered to the subjects in two separate lists that were parts of a larger questionnaire on social factors affecting creativity. For one list, the men were instructed as follows: "Different kinds of abilities make for success in different companies. From your experience and observation, what pays off for success in this organization? Please rank order the items from the one which is most rewarded to that which is least rewarded in this company." For the second list, the men were instructed as follows: "From the point of view of encouraging and promoting creative ability in a research organization, what abilities and activities do you believe should be most rewarded and recognized and what should be least rewarded and recognized? Please rank order the activities listed below according to the extent to which rewarding them would serve to promote creative research."

It should be noted (Table 2) that there was good agreement among the raters at each of the supervisory levels in the rankings they assigned the items for success and for creativity. The better agreement reflected in the higher concordance values for creativity suggests that this matter may be clearer for our subjects or "creativity" may evoke stereotypes, while success may vary more with the individual perceptions of the characteristics of the different companies.

With the above in mind, let us turn to the first question: To what extent are the skills and abilities necessary to attain and fulfill both success and creativity value orientations congruent? Figure 1 was constructed by obtaining the rank order correlations between each man's ranking of the items for success and his ranking of the items for creativity. The mean rho for each supervisory level was then obtained.

Level 5 -- Has administrative and technical responsibility for two or more groups. Each group is headed by someone who has been classified as "3" or "4". A man in this supervisory level need not directly supervise the technical work of his groups (N = 5).
Level 6 -- Has administrative responsibility for a division of the research organization. In all but two cases, subjects of Levels "1" through "5" were drawn from these divisions. These administrators participated in the rating procedures by means of which the men in Levels "1" through "5" were selected for study (N = 12).
Level 7 -- Has administrative responsibility for the overall research organization. In two companies, this included the Vice-Presidents in Charge of Research (N = 7).

Table 1

Skills and Abilities for Different Roles[3]

	Role	Skill and/or Ability	Identifying Phrase
1.	Scientific	Making original discoveries of theoretical value for the growth of scientific knowledge	IGT: information gain, theoretical
2.	Scientific	Effectively communicating ideas and findings through writing or speaking to other scientists	CT: communication, theoretical
3.	Professional	Originating and developing ideas for useful products and processes	IGE: information gain, economic
4.	Professional	Effectively "selling" ideas and findings through writing or speaking to management or customers	CE: communication, economic
5.	Administrative	Planning and directing the research or technical programs of other professional men	AdR: administration, research
6.	Administrative	Planning for and solving problems of facilities, services, finances, or personnel for research	AdM: administration, maintenance
7.	Social	Getting along well with colleagues in the research organization	SI: social, internal
8.	Social	Working in close cooperation with salesmen and customers	SO: social, outside
9.	Social	Knowing the right people	S3: social, 3rd item
10.	Employee	Carrying out the routine aspects of the work efficiently and accurately	ER: employee, routine
11.	Employee	Developing and carrying out the scientific ideas of others	ES: employee, subordinate
12.	Autonomy	Independently carrying out your own ideas	Au: autonomy

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[3] The questionnaire and role items are published by Science Research Associates, Chicago, Illinois.

Table 2

Concordance Values (W) for Item Rankings of Success and Creativity at Each Supervisory Level

Supervisory Level	Success	Creativity
1. (N = 26)	.74	.70
2. (N = 15)	.62	.57
3. (N = 15)	.47*	.72
4. (N = 6)	.57	.76
5. (N = 5)	.47	.66
6. (N = 12)	.42	.70
7. (N = 7)	.42	.63

*p =< .01, for all others p = < .001.

The average correlations range from a low of .12 for the men lowest in the supervisory hierarchy to a high of .83 for the top level administrators. It is apparent from these correlations that less conflict is perceived between success and creativity by the top level administrators than by the men lower in the administrative or supervisory hierarchy. The higher correlation between the two variables for the top level administrators is generally consistent with the attitudes they express in management journals, talks before professional meetings, or in job advertisements -- industrial research allows for both creativity and success. The relatively lower correlations of the researchers themselves, however, tell us a different story. They suggest that the skills and abilities required for success are different from those required for creativity. In other words, the men actually conducting the research perceive more value conflict than do their top administrators. As will be seen later, the men at different supervisory levels differ in their perceptions both of what makes for success and what makes for creativity. This may represent actual differences, or -- if we assume that the data here are similar to those which would be obtained in a longitudinal study -- it may represent the process of conflict resolution. On the basis of data to be presented later, we are inclined to the latter view.

The perceived value conflict at Level 1 adds to the complexity the researcher experiences, for not only does he have to deal with complex research problems, but he also has to cope with complex situations or value decisions if he wishes to continue within the social matrix of industrial research.

The question may be asked how can the research organization maintain and perpetuate itself if such conflict is perceived at the lower levels of supervision. A partial

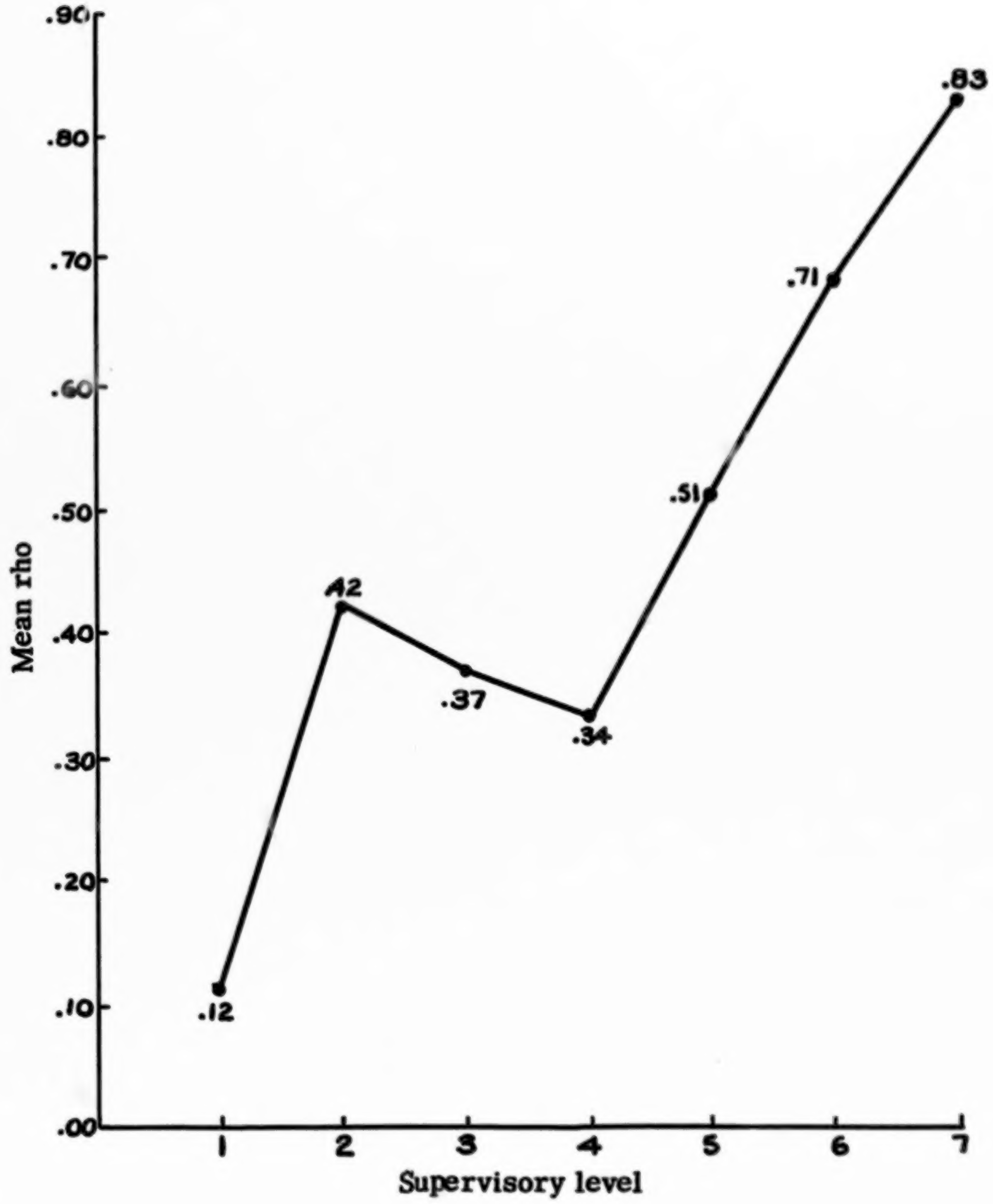

Figure 1. Rank order correlations between success and creativity within supervisory levels.

answer to this question is contained in data to be reported later, from which it will be apparent that an acculturation, socialization or industrialization process occurs in which as a man rises in the administrative hierarchy, his attitudes on success and creativity become more and more similar to those expressed by the men high in the research organization. Or, it may be possible that only those men are selected for the higher supervisory levels whose value orientations are in line with those of their superiors.

Let us now look at how each of the success and creativity items varies with supervisory status. They will tell us how the supervisory groups differ from each other. In preparation for the discussion that follows, the data were analyzed in three ways. Within each supervisory level each item was tested against every other item. The results of this analysis for success are presented in Table 3 and for creativity in Table 4.[4] Within levels, the creativity ranking of an item was tested against its success ranking. These data are presented in Table 5. The third type of analysis was a test of the differences between levels. Only those items that appeared by inspection to yield a significant difference were tested with the Kruskal-Wallis H test, two-tailed. Since not all the items were tested, no table is presented, but the relevant statements appear in the text. The discussion of between-level differences, however, is not limited to significant differences but includes mention of other variations that may be of heuristic value.

In the professional role following Hughes' (1952) definition of the term, the researcher is employed to give "esoteric service" to his clients. He fulfills this role by using his scientific knowledge and training for the selection and development of ideas that fit into the framework of the company's overall goals. In our list of role items, the professional role was represented by two: "Originating and developing ideas for useful products and processes" (IGE, information gain, economic) and "Effective selling of ideas and findings through writing or speaking to management or customers" (CE, communication, economic).

At all levels IGE obtains either the first or second highest average rank for both creativity and success. With the exception of Level 3, there are no significant differences between the average ranks it receives for creativity and success within any level. Thus, it may be said that of all the role items, IGE is the most critical in the industrial research environment. That individual researcher is most likely to be successful and should be most rewarded who can originate and develop ideas for useful products and processes. CE, the effective selling of ideas to management and customers, however, is ranked between 6.0 and 7.0 by all levels for creativity, and between 3.0 and 5.5 for success. At four out of the seven levels, it is ranked significantly higher for success than for creativity. It is interesting that the men in supervisory Level 1 assign CE an average rank that tends to be somewhat higher than that assigned to it at the other two low echelons (2 and 3). This may reflect the importance that this group attaches to communication with management and customers as a means of bringing themselves to the attention of others.

"Making original discoveries of theoretical value for the growth of scientific

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[4] The results are also presented graphically in Figure 2.

Table 3

Significant Differences between Ranking of Role Items for Success Within Supervisory Levels

Level 1	Level 2	Level 3	Level 4	Level 6	Level 7
1* CE	1 IGE	1 AdR	1 IGE	1 IGE	1 IGE
IGT	IGT	IGT	IGT	IGT	IGT
CT	CT	CT	ER	CT	CT
AdM	AdM	AdM	ES	CE	CE
SO	SO	SO	Au	AdM	AdM
S3	S3	S3		SI	SI
ER	ER	ER		SO	SO
ES	ES	ES		S3	S3
Au	Au	Au		ER	ER
				ES	ES
				Au	Au
2 IGE	2 SI	2 IGE	2 AdR	2 AdR	2.5 AdR
IGT	IGT	IGT	IGT	IGT	AdM
CT	CT	CT	SI	SO	SO
AdM	AdM	AdM	SO	S3	S3
SO	SO	SO	S3	ER	ER
S3	S3	S3	ER	ES	Au
ER	ER	ER		Au	
ES	ES	ES			
Au	Au	Au			
3 SI	3 CE	3.5 SI	3 CE	3 CT	2.5 CT
IGT	AdM	IGT	IGT	SO	SO
CT	SO	SO	ER	S3	S3
SO	S3	S3	ES	ER	ER
S3	Au	ER	Au	Au	Au
ER		Au			
ES					
Au					

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*The presentation of items to be compared is in order of their median rank. Beneath the main item are listed all those ranked significantly lower. For example, in Level 1, CE obtained the highest median rank and it was significantly higher than IGT, CT, etc. In view of the large number of calculations, a cut-off point of p = .01 or less (2-tailed) was established for reporting significant differences in the above list. Levels 4 and 7 are exceptions because the N in each group does not permit obtaining a level of significance beyond .05 and .02 respectively. Level 5 is omitted because no test of significance is applicable.

Table 3 (continued)

Level 1	Level 2	Level 3	Level 4	Level 6	Level 7
4 AdR IGT CT AdM SO S3 ER ES Au	4.5 AdR AdM SO S3 ER ES Au	3.5 CT IGT SO ER Au	4 SI ER	4 SI S3 ER	4 CE SI SO S3 ER
5 AdM IGT ER	4.5 CT S3	5 CE IGT SO ER Au	5.5 AdM ER	5 CE SO S3 ER	5.5 SI S3 ER
7 CT IGT SI ER	6.5 IGT	6 ES ER	5.5 CT IGT ES	6.5 AdM SO S3 ER	5.5 IGT S3
7 ES IGT ER	6.5 ES	7.5 S3	7.5 S3	6.5 ES SO S3 ER Au	7 ES S3
7 S3 IGT	9 AdM	7.5 AdM	7.5 Au	8 IGT SO S3 ER	8 AdM S3
9.5 SO	9 S3	9 IGT	9.5 ES	9 Au	9 Au S3
9.5 Au IGT	9 Au	10 ER	9.5 IGT	10 ER	10.5 ER S3
11 ER	11.5 SO	11 Au	11 SO	11 SO	10.5 SO
12 IGT	11.5 AdM	12 SO	12 ER	12 S3	12 S3

Table 4

Significant Differences between Ranking of Role Items for Creativity Within Supervisory Levels

Level 1	Level 2	Level 3	Level 4	Level 6	Level 7
1.5* IGT	1.5 IGE	1 IGE	1.5 IGT	1 IGE	1 IGE
CT	CT	CT	CT	IGT	CT
CE	CE	CE	CE	CT	CE
AdR	AdR	AdR	AdM	CE	AdR
AdM	AdM	AdM	SI	AdM	AdM
SI	SI	SI	SO	SI	SI
SO	SO	SO	S3	SO	SO
S3	S3	S3	ER	S3	S3
ER	ER	ER		ER	ER
ES	ES	ES		ES	ES
	Au				
1.5 IGE	1.5 IGT	2 IGT	1.5 IGE	2 AdR	2.5 AdR
CT	CT	CE	CE	AdM	AdM
CE	CE	AdM	AdM	SI	SO
AdR	AdM	SO	SI	SO	S3
AdM	SI	S3	SO	S3	ER
SI	SO	ER	S3	ER	
SO	S3				
S3	ER				
ER					
ES					
3 Au	3 AdR	3 AdR	3 AdR	3 IGT	2.5 IGT
CE	AdM	CE	CT	SO	SI
AdM	SI	AdM	CE	S3	SO
SI	SO	SI	AdM	ER	S3
SO	S3	SO	SO		
S3	ER	S3	S3		
ER		ER	ER		
ES					
4.5 CT	4 Au	4 Au	4 Au	4 CT	4 CT
CE	AdM	AdM	SI	SO	SO
AdM	SI	SO		S3	S3
SI	SO	S3		ER	
SO	S3	ER			
S3	ER				
ER					

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* cf. footnote Table 3.

Table 4 (continued)

Level 1	Level 2	Level 3	Level 4	Level 6	Level 7
4.5 AdR AdM SO S3 ER	4 CT AdM SI SO S3 ER	5 CT AdM SO S3 ER	5.5 ES SO S3	5 ES SO S3 ER	5.5 Au S3 ER
6 ES SO S3 ER	4 ES AdM SO S3	6 SI SO S3 ER	5.5 CT AdM SO S3	6 SI SO S3 ER	5.5 CE SO S3 ER
7.5 SI SO S3	7 CE AdM SO S3	7.5 ES AdM SO S3 ER	7 CE AdM SO S3	7.5 Au S3 ER	7.5 ES S3
7.5 CE SO S3	8.5 SI AdM SO S3	7.5 CE SO S3	8 SI SO S3	7.5 CE SO S3	7.5 SI SO S3
9 ER SO S3	8.5 ER AdM SO S3	9 ER SI SO S3	9 ER SO S3	9 AdM SO S3	9.5 AdM S3
10 AdM S3	10.5 AdM	10 AdM S3	10 AdM	10 SO	9.5 ER S3
11 SO	10.5 SO	11 SO	11 SO	11 ER S3	11 SO S3
12 S3	12 S3	12 S3	12 S3	12 S3	12 S3

knowledge" (IGT, information gain, theoretical), and "Effectively communicating ideas and findings through writing or speaking to other scientists" (CT, communication, theoretical) are the two scientific role items. In his scientific role, the researcher does not have clients, but orients himself in terms of the ethos of modern science and seeks truth (Merton, 1949). Here we find one of the major discrepancies between what makes for success and what should be rewarded for creativity. At no level does the ability to make original discoveries of theoretical value for the growth of scientific knowledge achieve an average rank higher than 6.0 for success and indeed, it has an average rank of 11.0 at the first supervisory level,[5] a point to which we shall return in a moment. Insofar as creativity is concerned, observe that it fluctuates between 1.5 and 4.0 for all supervisory levels. At all levels, it is ranked significantly higher for creativity than for success. Thus, while all supervisory levels acknowledge the fact that discoveries of theoretical value for the growth of scientific knowledge are among the more important factors to be rewarded to stimulate creativity, skills and abilities in this area are not as important for success in the culture of industrial research. The level at which the greatest conflict is perceived is Level 1. This is what we believe to be a cross-cultural shock effect. Although the men in Level 1 have been employed in their respective companies for an average of four years, it is suggested that they are still under the influence of their academic cultures in which contributions to scientific knowledge are highly valued. They have not yet become acculturated to their industrial environments. Indeed, some men in one company (not one which is included in the study reported here) told us that while it may take four years or so to obtain the academic Ph. D., it takes about three or four more years to get the "industrial Ph. D.". (For these trends, see Figure 2.)

The second item in the scientific role, communicating ideas or findings through speaking or writing to other scientists (CT), does not obtain markedly different rankings whether it is ranked for creativity or success, with one exception. At Level 1, it is ranked significantly higher for creativity than for success. It should be noted, however, that for success, there is a tendency for this item to increase somewhat in importance for Levels 5 through 7. This may reflect the importance of the scientific peer group and colleagues for supervisory personnel at the higher echelons. Top supervisory personnel cannot always keep up with recent scientific and theoretical developments in all fields. Nevertheless, they can utilize the opinions of a man's peers and colleagues for evaluating his ideas. If a man can support his ideas and work in the face of colleagues' criticisms, or if they react favorably, or at least with interest, then top level supervisory personnel has at least some indication that it might be worthwhile to support a man in his work.

It should also be noted that within Levels 1, 3, and 4, communicating with one's fellow scientists is ranked significantly more important for success than is making original discoveries of theoretical value for the growth of scientific knowledge. Though not significant, the trend for the other levels is the same. This, together with the fact that at all levels IGT is ranked significantly lower than IGE suggests that the researcher may be expected to utilize his theoretical knowledge or to be conversant with theoretical developments if he wants to be successful, but that he should not be seduced into making contributions to theory for it is more important to use his knowledge for work that will "ring the cash register" (IGE). If this is so, then it may also be that the researcher may have to keep abreast of theoretical developments while off the job, on his own time, or in the time he can find between on-the-job activities, if he has to use them in his day-to-day activities. Another interpretation of the CT data is that they may reflect the importance of playing the role of scientist -- the importance of being acknowledged and accepted by others as a researcher in the industrial environment.

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[5] The average rank of this item at Level 1 is significantly lower than for all other levels.

Autonomy (Au), or the skill and ability to carry out one's own ideas independently, relates primarily to the scientific and professional roles, although it may also be related to the others. The rankings that this item receives for success and creativity are quite discrepant. In five of the seven supervisory levels, it is ranked significantly higher for creativity than for success and at the other two levels the trends are in the same direction. For creativity the range of average ranks is from 3.0 to 6.5, and for success, the range is from 7.5 to 9.5. The reason for this discrepancy may lie in the fact that carrying out a research problem with real effectiveness often depends on the labors and ingenuity of the individual investigator even though he may be influenced in his thinking and approach to the problem by his interaction with others. Industrial research, as well as research in other institutional settings, is, however, a social process. It involves convincing others as to the value of an idea before funds are expended to explore it. It involves working with groups of people and perhaps even absorbing oneself in more than one project. Therefore, for success, autonomy may not be of prime importance. It may be more important to be able to delegate authority and responsibility to others and to accept others' authority.

While autonomy is critical for creativity (e.g., the creative individual implicitly or explicitly questions the present status of his field or work area), it is implicit in the fact that research occurs in a social matrix, that the system contains forces that might inhibit one of the very factors that it should seek to encourage. The pressures for communication, for getting along well socially with others, for administration, etc., are all factors that might inhibit or restrict autonomous striving. While autonomy may be critical for facilitating a man's progress, vis-à-vis his problem, it may impede his progress in industrial research unless he can distinguish between the area of his problem and the social matrix within which he works -- another reflection upon the complexity of the social matrix within which the creative individual must operate.

With regard to the autonomy item, it should also be noted that not only do the lower supervisory echelons tend to rank it higher than the upper echelons with regard to creativity, but that there is a greater discrepancy in the success and creativity rankings at the lower than the upper levels. This suggests that the pressure for group participation is felt more by the lower than the upper echelons.

The next role to be considered is the administrative role. Two items in the questionnaire referred to this role. One related to the Administration of Research (AdR), "Planning and directing the research or technical programs of other professional men," and the other to the Administration for Research (AdM), or "Planning for the solving problems of facilities, services, finances or personnel for research." The second refers to activities necessary for the maintenance of the research organization.

For creativity, AdR starts with a low of 5.0 at Level 1, and moves up to a rank of 3.0 at Level 4. After dipping at Level 5, it rises to ranks 2 and 3 at Levels 6 and 7

Table 5

Median Ranks of Role Item for Creativity and Success at Each Supervisory Level

Role	Level 1 (N=26)				Level 2 (N=15)				Level 3 (N=14)				Level 4 (N=6)			
Item	Cr.	Suc.	T*	p	Cr.	Suc.	T	p	Cr.	Suc.	T	p	Cr.	Suc.	T	p
IGT	2.0	11.0	1	.01	2.0	7.0	7	.01	3.5	8.5	0	.01	1.5	9.0	0	.05
IGE	2.0	3.5	--	NS	2.0	2.0	--	NS	1.0	3.0	7	.05	1.5	1.5	--	NS
CT	5.0	7.0	56	.02	5.0	5.0	--	NS	5.0	5.0	--	NS	5.5	6.0	--	NS
CE	7.0	3.0	16	.01	7.0	4.0	7	.01	7.0	5.5	--	NS	7.0	3.5	0	.05
AdR	5.0	4.5	--	NS	4.0	5.0	--	NS	4.0	1.0	10	.05	3.0	2.0	--	NS
AdM	10.0	6.0	5	.01	10.0	9.0	--	NS	9.5	7.5	--	NS	9.0	6.0	--	NS
SI	7.0	4.0	26	.01	8.0	3.0	0	.01	6.0	5.0	--	NS	8.0	5.5	--	NS
SO	11.0	9.0	25	.01	10.0	10.0	--	NS	11.0	11.0	--	NS	11.0	10.5	--	NS
S3	12.0	7.0	2	.01	12.0	9.0	3	.01	12.0	7.5	2.5	.01	11.5	7.5	--	NS
ER	8.5	10.0	--	NS	8.0	10.0	--	NS	8.5	9.0	--	NS	8.5	11.0	--	NS
ES	6.5	7.0	--	NS	5.0	7.0	10	.01	7.0	7.0	--	NS	5.5	9.0	--	NS
Au	3.0	9.0	20.5	.01	5.0	9.0	1	.01	4.5	9.5	4.0	.01	4.0	7.5	--	NS

*Wilcoxon matched-pairs signed-ranks test (Siegel, 1956).

Table 5 (continued)

Role Item	Level 5 (N=5) Cr.	Suc.	T*	p	Level 6 (N=12) Cr.	Suc.	T	p	Level 7 (N=7) Cr.	Suc.	T	p
IGT	3.5	6.0	--	--	4.0	6.5	3.5	.05	3.0	6.0	1	.05
IGE	2.0	2.5	--	--	1.0	2.0	--	NS	1.0	1.0	--	NS
CT	3.5	4.5	--	--	4.5	4.0	--	NS	5.0	3.0	--	NS
CE	6.0	3.5	--	--	6.5	5.0	13.5	.05	6.0	4.0	--	NS
AdR	4.5	4.0	--	--	2.0	3.0	--	NS	3.0	3.0	--	NS
AdM	9.0	6.5	--	--	7.0	6.0	--	NS	9.0	8.0	--	NS
SI	8.0	8.0	--	--	6.0	4.5	--	NS	8.0	6.0	--	NS
SO	11.0	8.0	--	--	9.5	10.5	--	NS	10.0	10.0	--	NS
S3	12.0	11.5	--	--	12.0	11.5	--	NS	12.0	12.0	--	NS
ER	10.0	10.5	--	--	10.0	10.0	--	NS	9.0	10.0	--	NS
ES	7.0	7.5	--	--	5.5	6.0	--	NS	8.0	7.0	--	NS
Au	3.0	8.0	--	--	6.5	9.5	1	.01	6.0	9.0	1	.05

*N too small for Wilcoxon test.

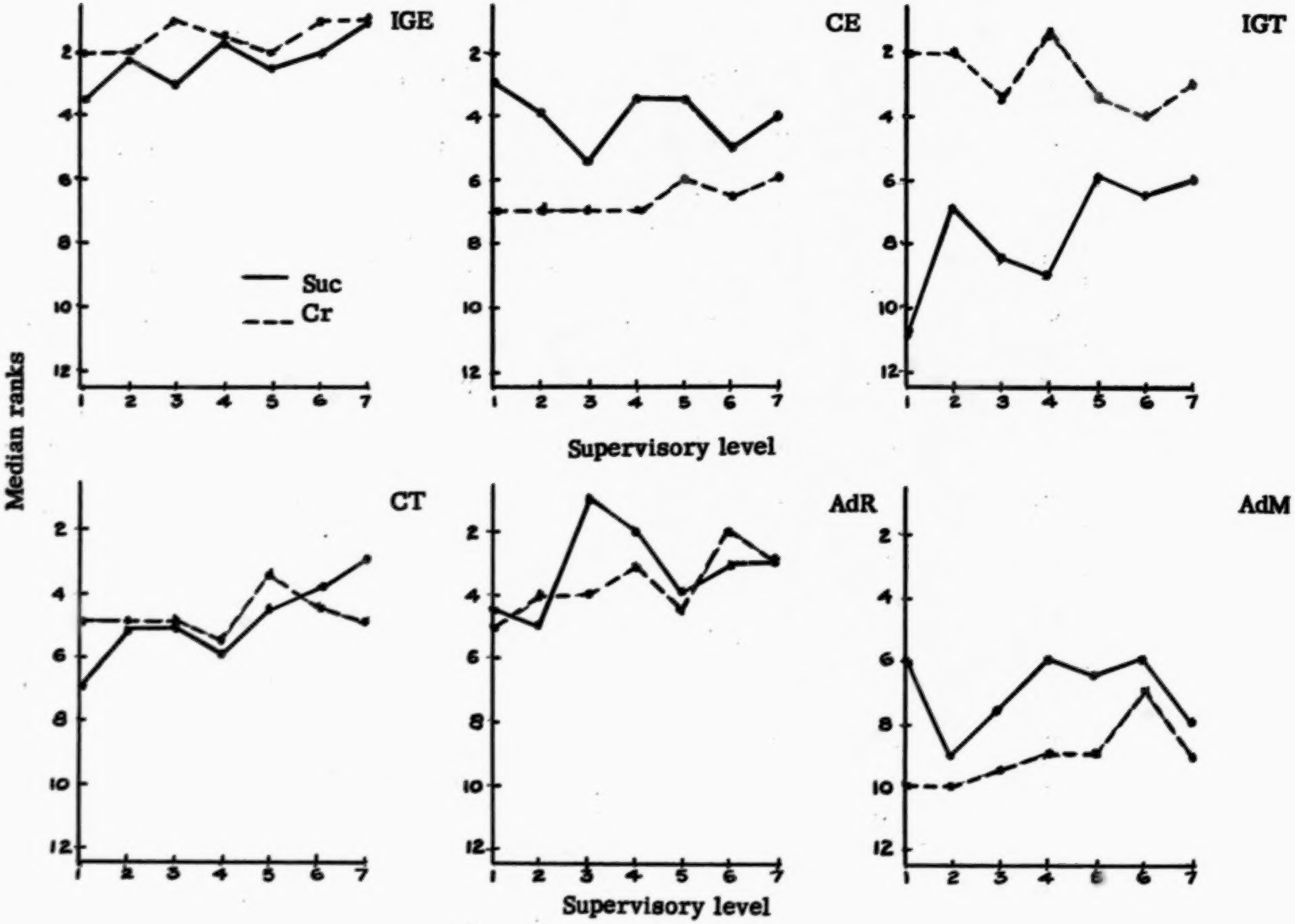

Figure 2. Variations in median ranks of role items for success and creativity as a function of supervisory level.

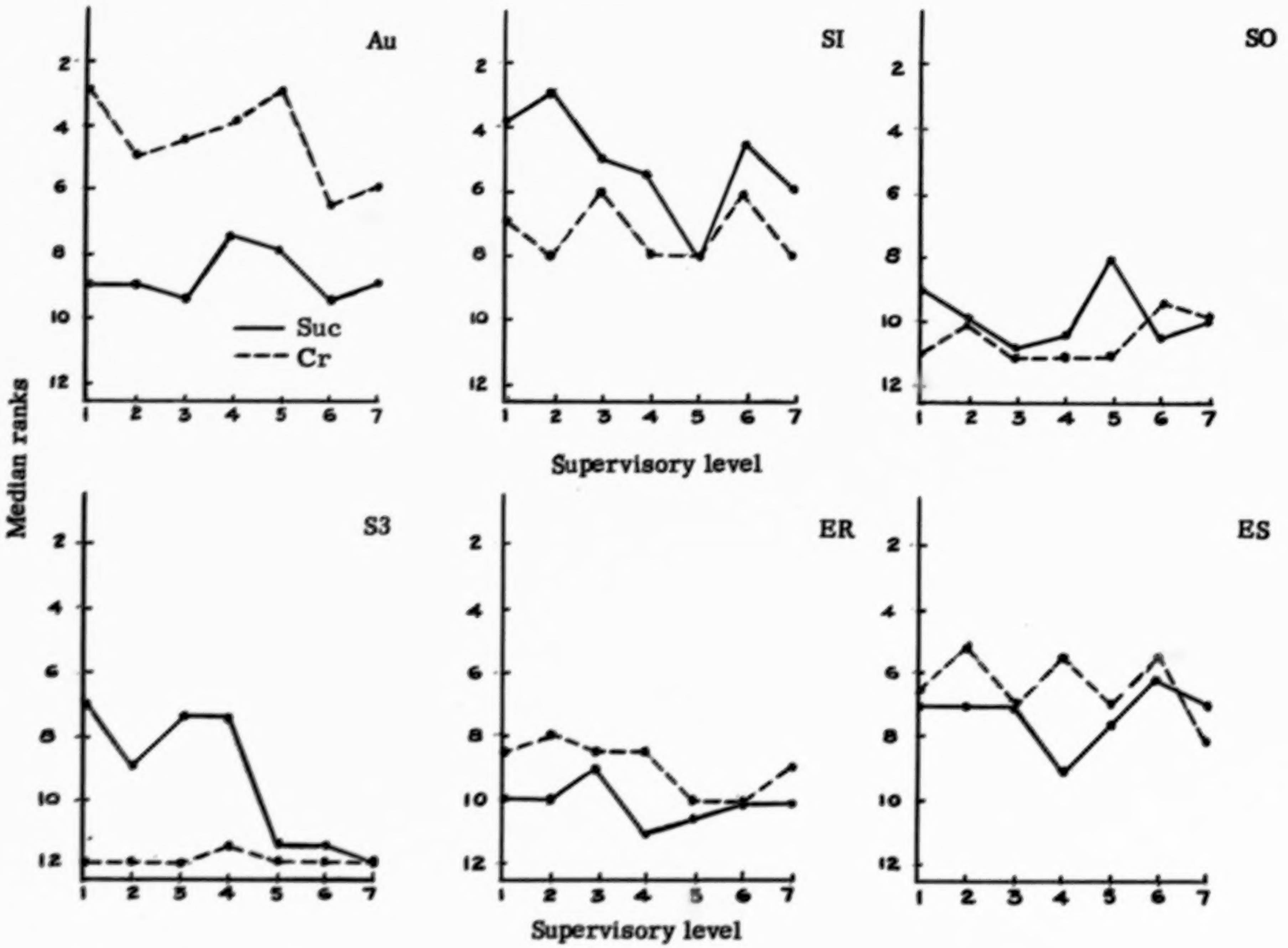

Figure 2 (continued)

respectively. Within each echelon after Level 1, it rises in importance relative to the other items. Apparently, Level 1, consisting of individuals who do not have much supervisory responsibility, is inclined to emphasize the role of the independent investigator while the others may see in AdR the opportunity to bring to fruition more ideas more rapidly. Only at Level 3 is there a significant difference between how this item was ranked for creativity and for success. Level 3 ranks AdR significantly higher for success than for creativity. This is the first level at which the researcher's supervisory responsibility is of sufficient magnitude to make him aware of the importance of planning and directing the work of other professionals in the industrial environment.

Furthermore, after the first two levels, AdR is ranked as first or second in importance for success relative to the other items. In most instances, it vies with IGE, thus reflecting the importance of AdR for success in industry.

The item related to Administration for Research (AdM) -- the "Planning for and solving the problems of facilities, services, finances or personnel for research" reflects the fulfillment of maintenance functions in research. Effective research cannot go on without it, but new information, new research findings, do not come directly, but only indirectly from it. Here, there is little disagreement among our men in the various supervisory levels that rewarding this skill and ability does not necessarily stimulate creativity, for it is ranked within the lowest quartile by all groups with the exception of Level 6, which assigns it an average rank of 7. Level 6 has major responsibility for the kind of paper work that is involved in AdM and in keeping a smoothly functioning operation going. They, more than the others, may be aware of how taxing it is and how ingenious one needs to be if these things are to be done well. For success, AdM is generally ranked 6 or below but at all levels it tends to be ranked even lower for creativity. Only at Level 1 is this difference significant. Different factors may account for the discrepancies at different levels. At Level 1, it is suggested, the men observe their superiors and come to believe that their responsibilities involve primarily the administration for research. The men at the other levels may also have ranked it higher for success than creativity because they may have seen a good many projects delayed or go down the drain because "administrative factors," "red tape," etc., were permitted to interfere with the progress of research. They may also believe that their own future progress will depend on keeping irritating administrative details at a minimum. Level 7 tends to rank this item slightly lower than the three previous levels. Here, we may have some indication of one of the major sources of conflict between the middle supervisory level and the top supervisory level in research. While the top supervisory level is pressing for ideas, for products, and processes that will "ring the cash register," the middle supervisory level, which often has to come across with these ideas, is so harrassed with paper work and the administration for research that they often complain that they cannot find the time to do everything that has to be done.

The fourth role of the industrial researcher is the social role. It refers to social relationships on the job and was represented in the list by three items: "The capacity to get along well with colleagues and superiors in the research organization" (SI), "Knowing the right people" (S3), and "The capacity to work in close cooperation with salesmen and customers" (SO). Almost all levels tend to rank "The capacity to get along well with colleagues and superiors in the research organization" higher for success than for creativity and this discrepancy tends to be greater at the lower than the upper levels of supervision; but it is significant only for the first two levels. The lower levels of supervision may regard it as more important for success than their superiors since they may believe that the capacity to get along well with colleagues and superiors may well be regarded as a sign of leadership. Top supervisory levels may not regard this capacity as highly as their subordinates for they may feel that "getting along" is not as important as getting the work out. It should be noted that the Level 7 administrators did rank communication with fellow scientists (CT) significantly higher for success than they did this social factor. It would appear, therefore, that they might want their men to test out their ideas on each other or to convince each other about the value and significance of their ideas and that this is more important than getting along with each other.

"Knowing the right people" (S3), is acknowledged by all levels, as one might expect, to be among the least important of all the factors for creativity. However, at the first three levels, the item is ranked significantly higher for success than for creativity. It should also be observed that for success, the average rank that the item receives at the three top levels is lower than it is at the first four levels of supervisors. It may be suggested that the top supervisory levels, who are among the "right people" are saying that their personal feelings toward a man have nothing to do with the types of decisions they make about his success. They may well regard themselves as "rational" or "objective" attending solely to the man's research accomplishments. On the other hand, their ratings may suggest, if we regard the data obtained from their subordinates as valid, that they may have forgotten (or desire to forget) their own trials and tribulations as they rose to the top. The men in the lower supervisory levels may regard "knowing the right people" as more important for success either as a rationalization ("sour grapes" attitude) for their own possible lack of success or because they have sufficient evidence that extra-scientific and extra-professional or subjective factors may have swayed certain administrative decisions.

The third item in the social role is the capacity to work in close cooperation with salesmen and customers. This is ranked next to last for creativity by all supervisory levels with only one exception. Only "knowing the right people" was ranked lower by all groups. For success, the range of average rankings is from 8.0 to 11.0. Spending time with salesmen and customers is what management generally tries to keep at a minimum for its researchers and in most instances, has a technical service staff to deal with these problems. In view of the relatively higher success ranking assigned by Level 5, it is possible that this group finds itself called upon more frequently than the others to spend time with salesmen and customers.

The last role of the industrial researcher is the employee role. In this role, he fulfills the function of a subordinate and it is represented by two items: "Developing and carrying out the scientific ideas of others" (ES), and "Carrying out the routine aspects of the work efficiently and accurately" (ER). In general, these items fall in the lower half of the group for both creativity and success and there is a tendency for ES to be ranked higher than ER. There is also a tendency for those men in Levels 1 through 4 to rank both of these items slightly higher for creativity than for success. It is likely that fulfilling the subordinate function is seen by these men as fulfilling training needs, as a means of learning how to become better scientists and professionals.

It is possible that the higher echelons may see the fulfillment of the same activities as an indication of greater involvement and integration into the purposes of the company.

Summarizing the data presented thus far, we find that there is greater disparity in the perception of the skills and abilities that should be rewarded to stimulate creativity and those that are rewarded for success among the lower echelons in the research hierarchy than there is among the upper echelons. The data presented here not only reflect some of the problems involved in the administration of research personnel, but they also suggest the areas of adaptation and acculturation required of the research man if he wishes to be both successful and creative in the present industrial environment. In general, he has to adapt his theoretical knowledge to practical purposes, be prepared to assume administrative responsibility, and adjust to the social requirements of industrial research.

In the foregoing, we have been concerned with the relationship between skills and abilities rewarded for success and those skills and abilities that should be rewarded to stimulate creativity as well as variations in the relationship as a function of supervisory status. Now let us turn to the second question: What is the degree of agreement on both success and creativity between those researchers in the lower echelons and those who constitute one of the power groups in the industrial environment? Stated somewhat differently, the question is, although there are differences in the perception of success and creativity as a function of supervisory status, is there any more definitive evidence than was presented previously for an acculturation process? Is it so that as men rise in the supervisory hierarchy, their attitudes and values become more and more similar to those at the top level of administration.

To answer this question, we can select as our top level administrators those at Level 6 or 7 or both. Since time does not permit us to discuss both comparisons, we have selected Level 6 for comparative purposes on the basis of the following rationale: Level 7 is composed of individuals who are known as "Directors of Research," "Managers of Research," or "Vice-Presidents in Charge of Research," etc. Although most of them rose from the ranks, and almost all of them have made significant research contributions, their jobs are largely involved with matters of policy and they may well be regarded, for our purposes, as the "symbolic" heads or spokesmen for research. Level 6, on the other hand, is composed of men who are called either "Department Heads" or "Division Directors." Although they, too, may be involved in policy matters, they are closer to the research activities of the men than are the men at Level 7. The men at Level 6 set the pace and tone for research and they may well be regarded as the "Actual" heads of research activities in the sense that it is their function to translate policy into concrete research plans which directly affect the men.

Figures 3 and 4[6] are based on the rank order correlations between each man and his own supervisor at Level 6 for creativity and success respectively. The mean

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[6] The figures are based on a smaller number of subjects than previously indicated since in a few instances it was impossible to pair a man with a single Level 6 supervisor. For the material presented here, the number of men are: Level 1, N = 22; Level 2, N = 14; Level 3, N = 13; Level 4, N = 6; Level 5, N = 4.

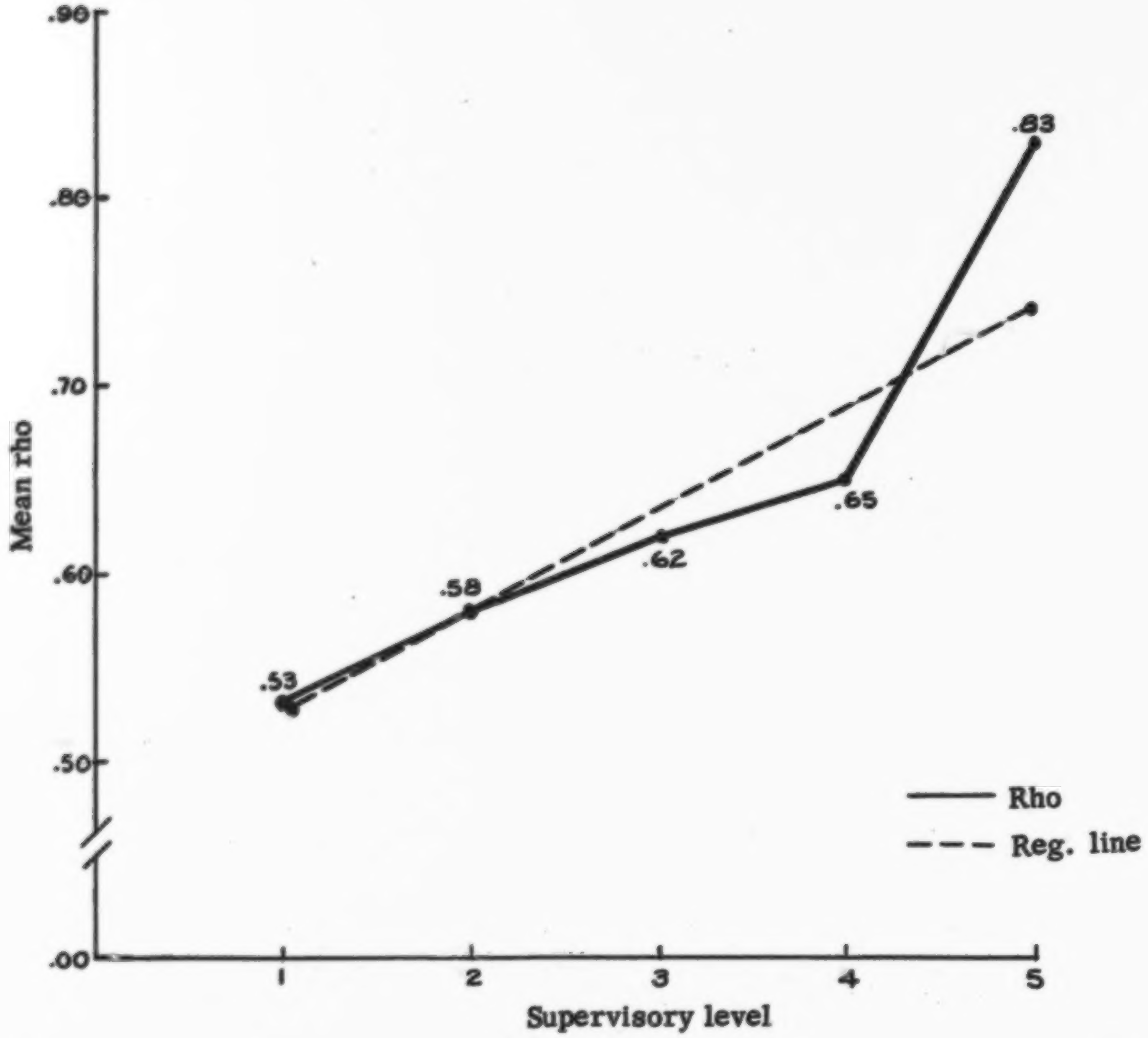

Figure 3. Mean rhos at Levels 1 to 5 between men's ranking of the role items for creativity and the ranking of the same items by their own supervisors at Level 6. The regression line fitted to these data is also plotted.

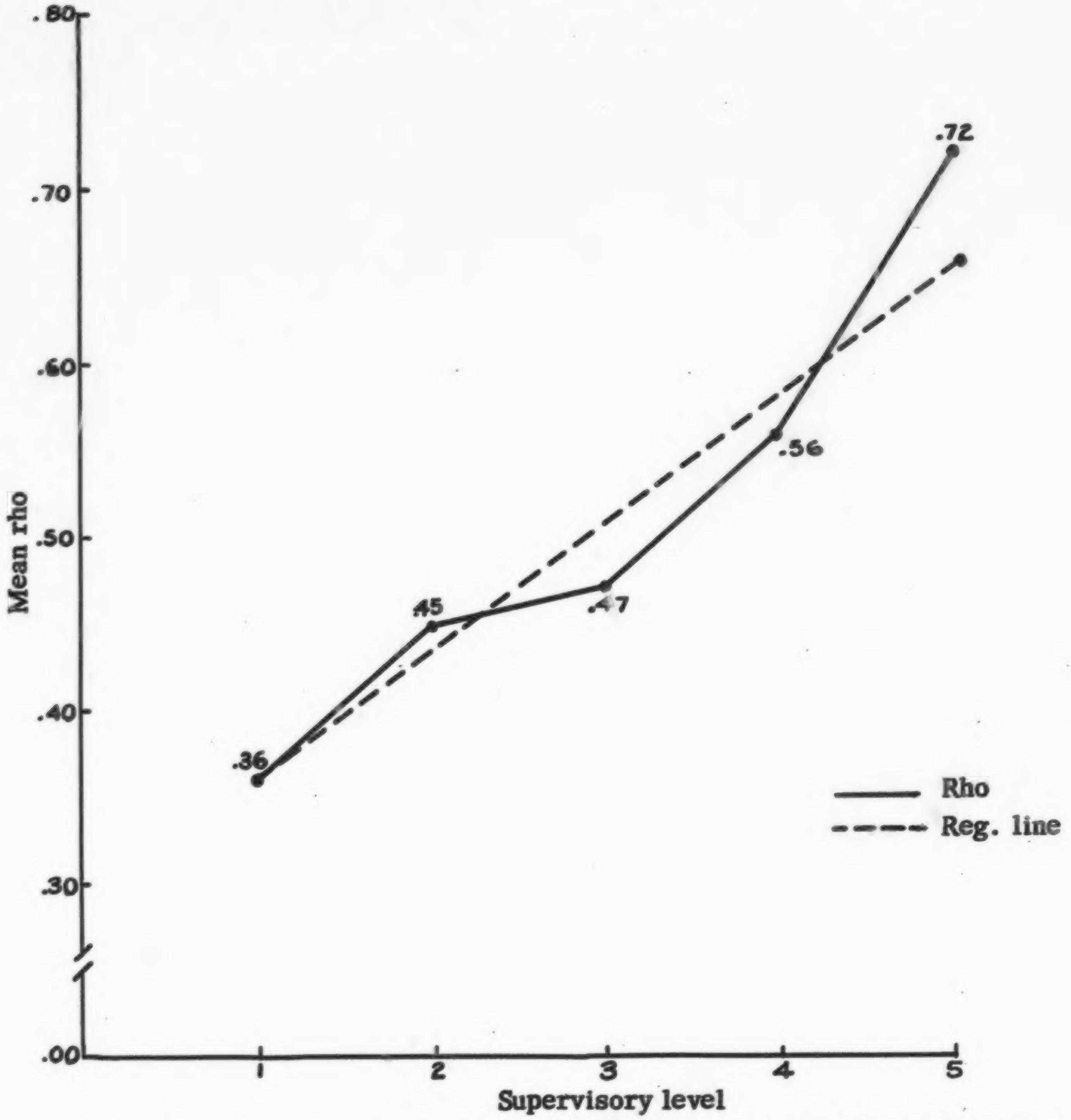

Figure 4. Mean rhos at Levels 1 to 5 between men's ranking of the role items for success and the ranking of the same items by their own supervisors at Level 6. The regression line fitted to these data is also plotted.

rho for each supervisory level (1 - 5) is plotted as well as the regression lines fitted to these data. For creativity the mean rho increases from .53 at Level 1 to .83 at Level 5 and for success, they increase from .36 to .72. The data yield regression coefficients (b) of .059 (p =<.02) and .072 (p =<.01) respectively. For both creativity and success data one might say therefore, that as men rise in the administrative hierarchy of industrial research, they become more and more similar to their top level supervisors. Is this only a function of supervisory level, or of other factors? To date, the only additional factor we have studied is the amount of time the man has spent in the company. Here we find that the regression coefficients are not significant. For creativity, the regression coefficient was .006 and for success, .005. Thus, although we have not ruled out all other factors, we are inclined to attribute the increasing similarity of the men from Levels 1 - 5 with their supervisors at Level 6 to increase in their own status.

The data suggest that there is evidence for an acculturation, learning, or socialization (industrialization) process that the researchers undergo. What the precise mechanisms in this process are is not yet clear. What parts identification, self-selection, intentional selection, etc., play are problems for the future. One factor that is apparent is that for the total group, the phenomenon does not occur merely as a function of time, but with increased status. Whether the status coalesces and solidifies already existing attitudes and values or whether it provides a new role for the man that he seeks to fulfill cannot be determined from the data presented here, but it is likely that both are involved.

With the overall acculturation process in mind, we turn to the third question: How do more and less creative men compare with their top level supervisors (at Level 6) in the perceptions of what makes for success and what should be rewarded for creativity?

It will be recalled that the basis for dividing the men into more and less creative groups was the ratings they obtained on a series of variables from their subordinates, peers, and superiors. Half the weight in determining a man's creativity rating was carried by his superiors' ratings (only those at Level 6 rated the men, and not those at Level 7), and half to those he obtained from his peers and subordinates.

Before turning to the data, let us anticipate a question that might be raised. The superiors at Level 6 rated the men on creativity and therefore, one might expect the more creative men to agree more with the superiors who rated them highly. In answer to this question, the following should be pointed out. The superiors' ratings had only half the weight and if the superiors' ratings did not agree with those of the man obtained from his subordinates and colleagues, then the man was omitted from the experimental sample. Secondly, even if we had replaced the actual head who did participate in the ratings with the symbolic head who did not, the overall curves would not vary too much in the point they make. Finally, the data themselves do not completely bear out the expectation. Since there is only one less creative man at Level 4 and no less creative men at Level 5,[7] the following discussion will be limited to the researchers at the first three supervisory levels. The data obtained for the two groups of men on creativity are presented in Figure 5. The regression lines fitted to these data are presented in Figure 6.

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[7] For the more and less creative men, the N's are respectively: Level 1, N=5 and 17; Level 2, N=7 and 7; Level 3, N=6 and 7; Level 4, N=5 and 1; Level 5, N=4 and 0.

For creativity, the correlations for the more creative men show no consistent trend. They move from .47 at Level 1 to .61 at Level 2, and drop to .53 at Level 3. For the less creative men, however, the correlation is .54 for the first two supervisory levels and then it jumps to .69 at Level 3. The regression coefficients for the two groups are .024 (NS) and .066 (NS), respectively. The two regression coefficients do not differ significantly from each other. As they move up the supervisory ladder, neither the more nor the less creative men come into greater agreement with their Level 6 superiors regarding what should be rewarded for creativity. Furthermore, at Level 3, the less creative men tend to be in significantly greater agreement with their Level 6 supervisors than is true of the more creative men ($t_e = 10.65$, $p =< .10$, two-tailed).[8]

With respect to success, quite a different picture exists. The correlations for the more creative men move from a low of .25 at Level 1 to .50 at Level 2 and .56 at Level 3. For the less creative men, however, the correlations remain substantially constant. They are .39, .40, and .39. The regression coefficients for the two groups are .139 ($p =< .05$) and -.002 (NS) respectively. The differences at Levels 1 and 3 between the more and less are significant only at the .20 level ($t = 3.44$ and 6.16 respectively, two-tailed). The difference between the two regression coefficients is significant at less than .10 level. Thus, in contrast to the data on what should be rewarded for creativity, these data indicate that as the more creative men rise in supervisory level, their views of what makes for success in the company come into greater congruence with the perceptions of their superiors at Level 6. This is not true of the less creative men.

A similar question may be asked now, regarding the data of the more and less creative men, as was asked during the presentation of the data for the total group. To what extent are the data presented in Figures 5 and 6 solely a function of supervisory status and to what extent may they be related to other factors? Again, the only additional factor studied thus far is the amount of time that the man has spent in the company. The regression coefficients are not significant for the more and less creative men for either success or creativity. Thus, at the present time, we are inclined to regard the data presented above as a function of increased supervisory status or role, at least for the first three supervisory levels.[9]

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[8] Health t equivalent (1955).

[9] When the regression coefficients are re-calculated so that among the more creative group, Levels 4 and 5 are included and among the less creative group, the one man at Level 4 is included, we do find one variation. The regression coefficient for both success and creativity as a function of supervisory level is significant for the more creative men, but no changes obtain for the less creative men. Further, the regression coefficient for success on time in the company tends to be significant ($p =< .10$) only for the more creative group. Because of these variations, it should be emphasized that the data in the text are limited to the first three supervisory levels. These variations also point to the desirability of orienting future research in such a fashion as to determine where status effects alone may be critical and where time in the company effects alone would be critical for determining role perceptions. These questions would probably best be answered in a longitudinal study.

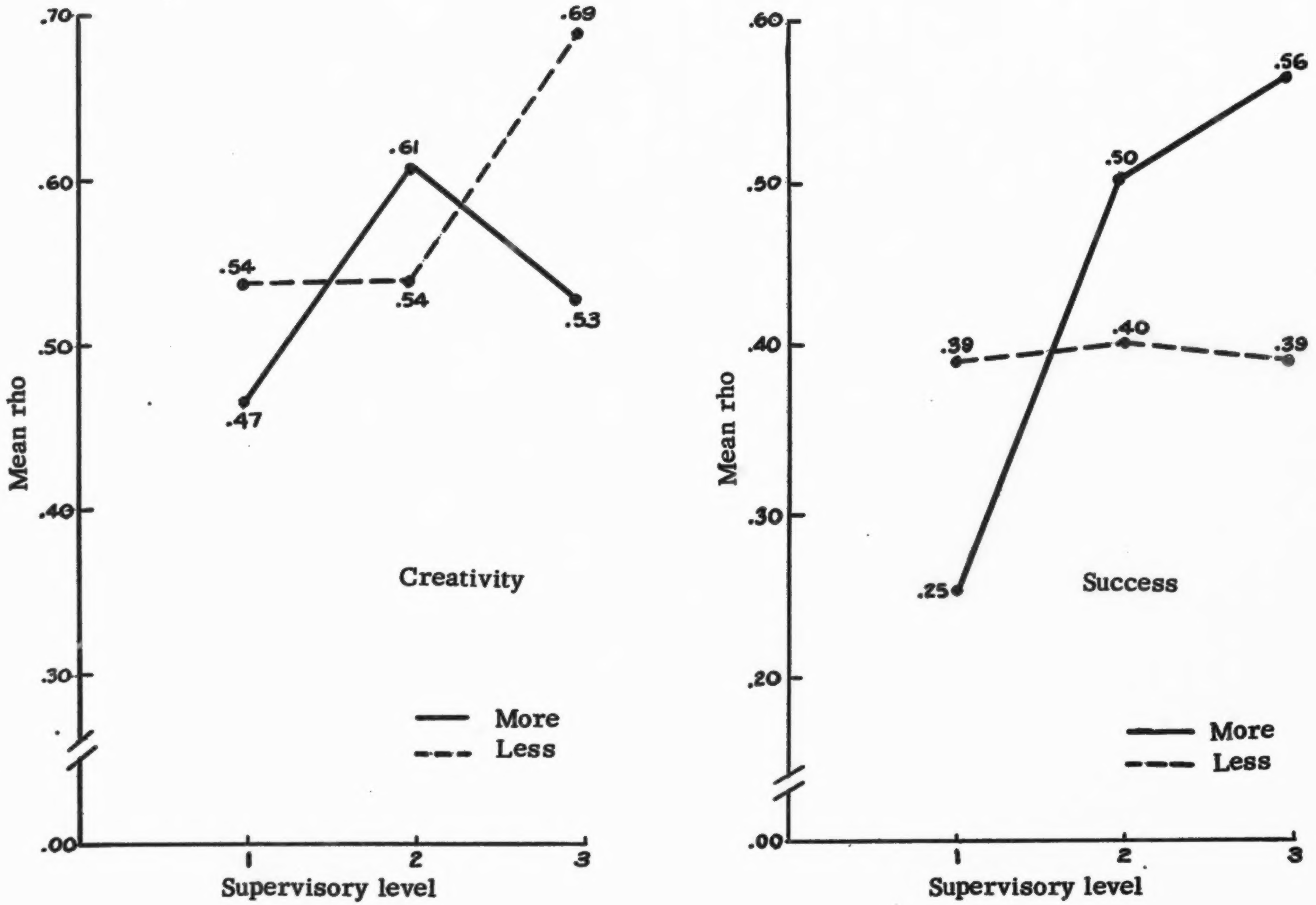

Figure 5. Mean rhos at Levels 1 to 3 between the more and less creative men's ranking of the role items and the ranking of the same items by their Level 6 supervisors.

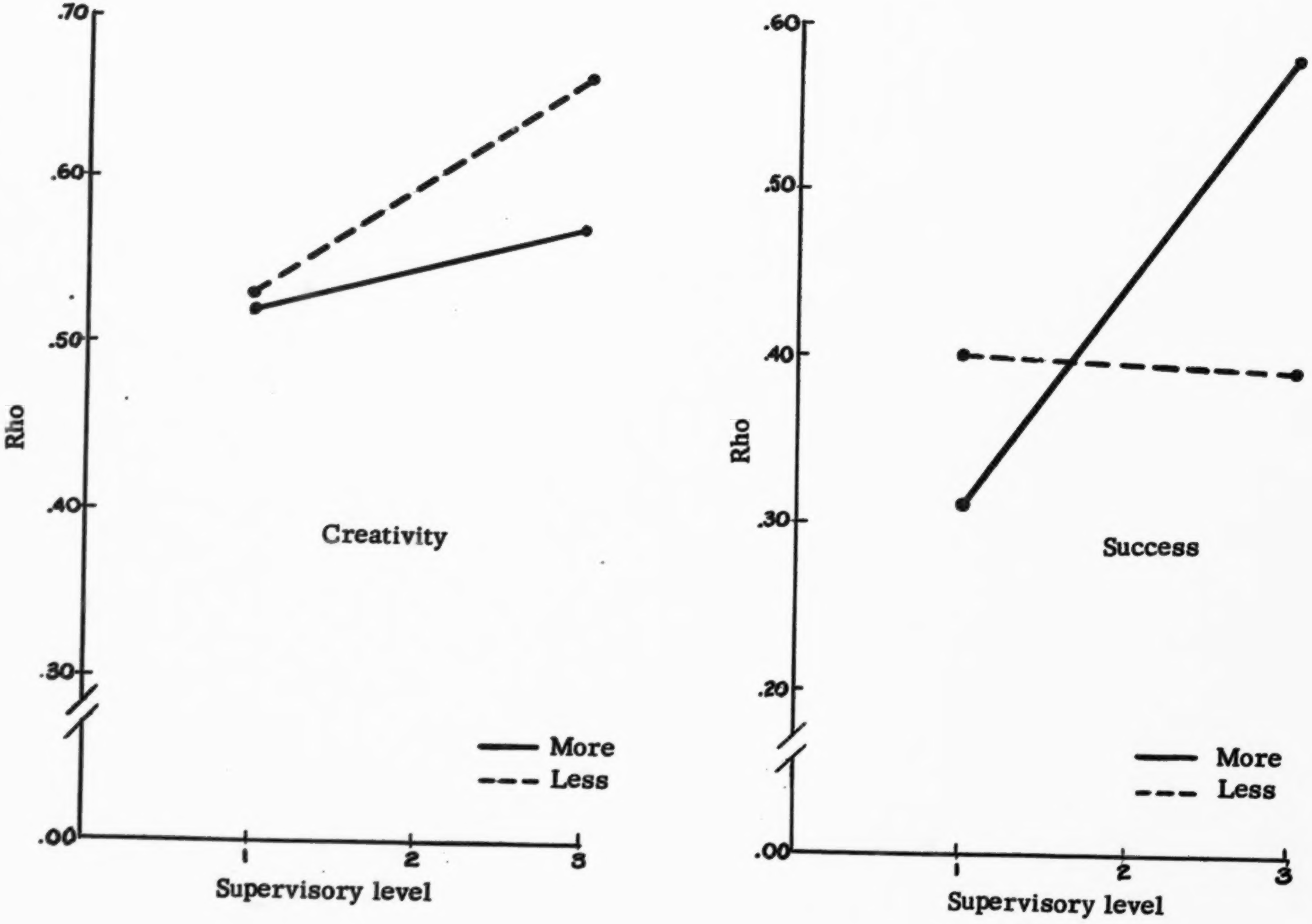

Figure 6. Regression lines fitted to data presented in Figure 5.

In view of the fact that the perceptions of the more creative men on what makes for success are more similar to their superiors' perceptions than are those of the less creative men, one might well ask the question whether they are "yes men" or "organization men." Several pieces of unpublished data on a slightly larger population of more and less creative men than those involved in this report suggest that this is not the case. For example, in our psychological data, the more creative men are less anxious, more autonomous and less concerned with avoiding blame than are less creative colleagues. When the two groups are asked whether they find the scientific knowledge and capacities of individuals responsible for the management of research a factor in impeding their creativity, 39% of the 33 more creative men say "yes" but only 12% of the less creative men say "yes" ($X^2 = 5.37$, $p =<.02$, two-tailed). It should also be noted that the extent of agreement between the more and less creative men and their superiors at Level 6 is in no instance of such magnitude as not to allow for disagreements. Consequently, we are not inclined to regard the more creative group as "yes men" but rather as more realistic individuals. They may be more perceptive of the realities of the situations in which they find themselves insofar as success is concerned. And, simultaneously, they may be able to disagree more than their less creative colleagues with their superiors at Level 6 as to what should be rewarded to stimulate creativity. It should be interesting to study these men some ten or fifteen years in the future to see whether they change their views or whether they reorganize industrial research in line with their present perceptions.

Before concluding the discussion, let us turn to how the more and less creative men at each of the first three levels differ in their perceptions of what makes for success and what should be rewarded for creativity (Table 6).

At Level 1, the more and less creative men differ significantly from each other on two items and there is a tendency for them also to differ on a third when these items are ranked for success. The less creative group ranked AdR (the administration of research) and ES (carrying out the scientific ideas of others) significantly higher than their more creative colleagues. SO (working in close cooperation with salesmen and customers) tended to be ranked higher by the more creative group. For creativity, the more creative group ranked two items significantly higher: CT (communicating with other scientists) and SI (getting along well with colleagues in the research organization).

At Level 2, there is a tendency for the less creative group to rank AdR lower and ES higher than do their more creative colleagues. And at Level 3, there are no significant differences between the two groups.

The items that are significant, as well as the trends in the other items, when they are ranked for success, suggest the possibility that at Level 1, the more creative men see more of the non-research activities as contributing to success. This may help to account for the fact that at this level they are not in as great agreement with their Level 6 supervisors as are the less creative men. Another possibility is that it may be evidence of some degree of cynicism on the part of the more creative men entering industry. When they rank the items for creativity, they point to the importance of communicating with their scientific colleagues. Is it possible that the more creative group makes up for its cynicism regarding success by turning to its

Table 6

Median of Role Item Ranks for Creativity and Success
for More and Less Creative Men at Supervisory Levels 1, 2, and 3

	Level 1								Level 2							
	Success				Creativity				Success				Creativity			
Role Item	M (N=5)	L (N=17)	H	p	M (N=5)	L (N=17)	H	p	M (N=7)	L (N=7)	H	p	M (N=7)	L (N=7)	H	p
IGT	12.0	11.0		NS	1.0	2.0		NS	7.0	6.0		NS	3.0	2.0		NS
IGE	1.0	4.0		NS	3.0	2.0		NS	2.0	1.0		NS	2.0	2.0		NS
CT	8.0	7.0		NS	3.0	6.0	5.43	<.05	6.0	3.0		NS	5.0	5.0		NS
CE	3.0	2.0		NS	8.0	7.0		NS	4.0	5.0		NS	6.0	8.0		NS
AdR	6.0	3.0	5.90	< .02	6.0	4.0		NS	3.0	6.0	3.43	< .10	4.0	4.0		NS
AdM	6.0	6.0		NS	10.0	10.0		NS	9.0	10.0		NS	10.0	11.0		NS
SI	3.0	4.0		NS	4.0	7.0	8.63	<.01	3.0	3.0		NS	9.0	7.0		NS
SO	4.0	10.0	3.68	<.10	11.0	11.0		NS	11.0	8.0		NS	11.0	10.0		NS
S3	4.0	7.0		NS	12.0	12.0		NS	8.0	10.0		NS	12.0	12.0		NS
ER	10.0	10.0		NS	10.0	9.0		NS	10.0	8.0		NS	9.0	8.0		NS
ES	8.0	7.0	3.84	<.05	7.0	5.0		NS	9.0	6.0	3.67	< .10	4.0	5.0		NS
Au	10.0	9.0		NS	3.0	3.0		NS	8.0	9.0		NS	3.0	5.0		NS

Table 6 (continued)

Level 3

	Success				Creativity			
Role Item	M (N=6)	L (N=7)	H	p	M (N=6)	L (N=7)	H	p
IGT	9.0	8.0		NS	3.0	4.0		NS
IGE	3.0	3.0		NS	1.0	1.0		NS
CT	6.0	4.0		NS	4.0	5.0		NS
CE	3.5	6.0		NS	6.0	8.0		NS
AdR	1.5	1.0		NS	3.5	4.0		NS
AdM	7.5	7.0		NS	9.5	8.0		NS
SI	5.0	5.0		NS	7.5	6.0		NS
SO	11.0	10.0		NS	11.0	10.0		NS
S3	8.5	6.0		NS	12.0	12.0		NS
ER	8.0	9.0		NS	8.5	8.0		NS
ES	6.0	7.0		NS	6.5	7.0		NS
Au	10.0	10.0		NS	3.0	6.0		NS

peer group for reinforcement on creativity? If so, then they may be encouraged by their peers to follow through on ideas and these may become stepping stones to success. By contrast, the less creative group appears to place more weight on items involving status relationships -- the administration of others or being a subordinate to others. Are their concerns with status such that it interferes with their work? Do they turn to status because of the difficulties they experience in their work? Or are they out of phase with the role demands at their level (they rank the AdR and ES items at Level 1 and 2 differently than their more creative colleagues)? These are questions that would require more intensive study than we have been able to devote to the problem at the present time.

In conclusion, we have presented in this paper, a study of an environment in which there is a potential as well as a real conflict between two values -- success and creativity. The evidence presented suggests that this conflict is not as intense at the upper supervisory levels as it is at the lower ones and that the diminished conflict may be accounted for by an acculturation process which is marked by increasing emphasis on the importance of administrative responsibility and the selection and development of ideas that meet the economic goals of the research organization as well as adaptation to its social requirements.

In the course of this paper, we have also touched upon characterizations of the environmental press that confront a man as he develops his career in industrial research. These factors are critical for those of us who are concerned with the prediction of creativity for from them, we may infer the characteristics an individual needs to possess if he is to actualize his creative potential.[10] We have also incidentally demonstrated the value of an instrument based on role analysis. We have not answered one of the most critical questions that confronts us both as citizens and as social scientists -- what would be the nature of the realistic creative accomplishments of our men if they did not have to withdraw some of their energies from problem solving and devote them to achieving success? Or, is the nature of research activity today such that it can be conducted only in a rather complex social matrix where we have to expect some loss and in which the researcher must be constantly alert to the choices he makes, whether they lead to creativity or to the condition that the broader society calls success?

Q--Did you make any analysis of these data in relation to salary or income?

S--No. You may be interested in knowing that in our total population the median starting salary for the more creative men is only slightly more than it is for the less creative men. At the time they were studied, there was a difference of $1,250 between median salaries.

Q--Is there a high relation between the administrative level and salary? Or is it quite conceivable that people of the second and third levels might be making just as good salaries as the fourth and fifth and sixth levels?

S--No. There is a relation between administrative level and salary even at the upper levels.

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[10] This issue has been discussed at greater length in Methods In Personality Assessment (Stern, Stein, and Bloom, 1956).

Q--What were the salaries of the more creative men the first year before they came to the company?

S--We have no data on that.

Q--Do your data shed any light on the possibility that there are places where paying off and creativity are seen in identical ways in contrast to environments and work situations where they are seen as quite different?

S--These same data can be analyzed for the differences between three companies.

Q--Is it your impression that there are differences between the companies?

S--Yes, but we have not as yet analyzed the data in this fashion.

Q--Are you in effect saying that environments can vary considerably with regard to variables like these?

S--Yes, but there are probably limits to this variation.

Q--I wish you would read again the statement on anxiety and autonomy and expand on it.

S--There were two related points in the paper. First, it was suggested that the individual who is anxious about personal matters and then is exposed to an environment in which there is a value conflict, may have difficulties in utilizing whatever creative potential he has. The value conflict may require energy for its resolution which is diverted from the work. It was also suggested that the more creative men, being less anxious and more autonomous, would be less inclined to merely agree with their superiors.

C--Yes, but you reported anxiety and autonomy as being discriminating between the more and less creative.

S--That is true. It was based on material that is not yet published.

C--But the more creative are more autonomous and also more anxious.

S--No, more autonomous, but less anxious.

Q--Wouldn't you say you are measuring creativity at the level of resourcefulness in the language used by Ghiselin -- that what is measured in the companies is short range kind of research?

C--Also, it seems to be that the industrial revolution deserves to be mentioned at some point in this because it has generated both a set of needs for certain kinds of talents and also a certain set of rewards which get to be summed up under success. I think that this meaning of success is very different from the meaning which success has for persons who perform creative acts or are dedicated to creative activity in the higher sense of the term. There we find chiefly the things like fidelity for one's ideals where love of truth in making total sense out of one's experience is important and being able to make some new meaning which will be recognized and so on -- those are the things that would be success to them.

S--Our approach is that in the industrial environment there is a developing culture with its own idea of what creativity is and what success is and these may be different from the ideals of science. Additional studies in universities and research institutes are necessary to see where these ideals do obtain.

C--Yes, a comment about halo and the dollar sign is relevant here because there is a sort of halo attached to the saintly heroic high level creative act but there is definitely a dollar sign attached to this one.

C--The people who shape the world with their ideas are rarely either subordinates or supervisors, I think.

Q--Who cannot be pinned down in a status hierarchy?

C--Yes, even in a case where they permit themselves to be patronized they always make it clear that their role is patronizer. But they are rarely on a payroll in this sense.

C--These are not people who in your sense are crystallized.

C--That's right. Although you cannot legislate verbal usage, I think it would be very useful if we could attempt to get at a different set of terms for these different things so that results can be assimilated to the proper context of meaning -- some of these distinctions in terms of resourcefulness, ingenuity, etc. It also has to be recognized that some of what we are talking about is simply the loyal, hard-working employee.

PREDICTOR COMMITTEE REPORT

Reported by
Frank Barron and Anne Roe

Barron--The predictor subgroup decided it could best make a contribution to the conference if it drew upon the knowledge of its members concerning available measures and techniques of description of attributes of persons in four general domains: (1) Intellectual aptitudes, (2) Temperament, (3) Motivation (under which one would probably subsume values), and (4) Life history information.

The committee recognized at the outset that any set of recommendations it might make for procedures in these areas would inevitably reflect to some extent the special interests of the members of the subgroup, but we hope that the basic spirit of the report will communicate a catholicity of taste in regard to suggested tests and techniques. We feel that in our present stage of ignorance concerning the correlates of creative talent, the best research approach should be broad-gauge and should, by policy, err on the side of inclusiveness rather than exclusiveness in deciding on the battery of tests which might be used. In brief, at this point in our approach to the problem it appears to us that the best strategy is to engage in a wide-ranging search for possible relationships and to include measures of sufficient diversity that patterns of interaction of variables can be discerned if they exist. The basic goal, as we see it, is to develop a set of predictor measures which will be practical aids to the identification at an early stage in the educational process of those individuals with creative potential, while at the same time including tests which may aid in conceptual clarification of the creative process.

Existent tests, which can be considered as reasonable candidates for inclusion in such a battery, should already be at such a stage of development and have been worked with in a sufficiently comprehensive and systematic way that their construct validity is reasonably assured. The pattern of intercorrelations of such tests with other soundly developed tests and with relevant nontest variables should already be known. At the same time, it should be recognized that there is a need of new tests in possible measurement areas which have not yet been adequately explored. In reference to this, the committee felt that it should call attention once again to the measurement needs which the aptitude-tests committee at the 1955 Utah conference on "The Identification of Creative Scientific Talent" pointed to in its report.

The research situation which the present committee imagined was one in which individuals of some demonstrated ability in scientific fields and announced intention to specialize in science in college and perhaps in graduate work, could be administered a very long battery of tests upon their graduation from high school, and then followed for a period of at least 15 years, during which period of time various intermediate as well as ultimate criteria for their actualized creativity might be determined. I think our feeling was that within 15 years some members of the criterion committee might have made some progress on the criterion problem. (Laughter.)

C--If they haven't deserted that committee by then.

S--This way of proceeding, then, is by imagining a research situation in which one is able to administer a very wide variety of tests (at this point without stating explicit hypotheses as to how they will relate to creativity), administering them at a very early stage in the development of a potential scientist, and allowing the criterion information to develop later so that one actually has predictors which may later work at the point where we want them to work, namely, for the early identification of creative potential.

Q--Are you recommending the "without hypothesis?"

S--Not necessarily. It is clear that some framework of thinking is affecting what measures one includes, but at this point the task defined for itself by the committee was not to state hypotheses and to suggest tests for them. I think if we did state hypotheses, we might be led to the construction of many new and highly relevant tests. But what we took as our task within our restricted time was essentially to survey available measures and, considering this kind of research situation, to put on the record the kinds of measures that are now worth recommending.

Q--What was your criterion for putting those on the record if not on the basis of at least implicit hypotheses?

S--We were thinking not in terms of hypotheses concerning creativity, but in terms of the broadest possible measurement of traits in the individual, with the notion that many relationships may turn up that we don't have the knowledge at the present time to hypothesize. We want to give them a chance to emerge, and, in addition, we want if possible to have a very wide coverage.

Q--Is this then going to be a list of all possible traits?

C--We did, of course, make some selection in terms of what might be potentially valid.

C--Yes, I think you must have.

S--I think, if I can speak for the group, my impression was that we were using the experience and hunches of the group, and nothing much more formal than that.

C--I think this is good to do.

S--I think there's quite another task which incidentally it might have been interesting to have a subgroup work on, and perhaps would have been more productive than this kind of task, and that would be to generate a very large set of hypotheses covering all of these things that we've talked about concerning conditions, criterion, and predictors -- an attempt to state hypotheses first and then look to whether or not there are available measures. However, I also think that there's great merit in allowing relationships to appear which are not presently hypothesizable by us.

C--You would be working on the basic hypothesis that there are "traits" or "factors" measurable which are related to the production of creative behaviors. This is the basic hypothesis, not necessarily one developed in some detail.

C--Perhaps even a little more than that, in terms of the experience of the people on this subcommittee. If they were selecting traits or instruments to bet on, these are the ones they would bet on.

S--Except for the fact that if you went at it hypothesis-wise, you would probably see immediately the need for new tests and for new ways of description.

Q--You don't feel that that is desirable?

S--I feel it's highly desirable. But that was not the task of the group. I say that I think that would be a good task ....

C--What you come up with is a list of the tests that in the judgment of this group are most promising for this sort of prediction.

S--That might be stated in a somewhat different manner.

C--It is reasonable that they should be used in a validation study.

C--I wonder if that isn't going a little far. I wonder if the problem of a committee like this is not so much to recommend what should be used as to give the newcomer into this field some notion of the variety of things that now exist.

C--I think that's right, because actually there are so many things that are mentioned that one couldn't possibly use all of them.

C--I think there's a different approach I'm hoping we will take, which is not so much one of saying, "Here are the recommended lists of things, " as saying, "Here are some of the things which we know are available which meet certain criteria, " but I think we're far from where we can say, "These are good ones and all the others are not."

C--Actually we've made a number of alternative suggestions of things that might be used for the same purposes.

S--Yes. For example, under each of these general domains there are different candidates which satisfy a certain kind of requirement. For example, one would probably want to include a vocabulary measure, and there are a number of good vocabulary measures in existence now. People naturally will choose that which in their experience seems to be very good for the purpose, and what we are recommending simply is that some such measure should be included without specifying which.

C--I think I still would take a different position than that.

S--Let me say briefly what our thinking has been. Our first thought was that a minimum requirement in any kind of survey of the potential of an individual for creative scientific work is to determine how he stands on various dimensions of intellectual aptitude. We considered that the basic principle should be, if possible, that one should use some sort of framework which would allow for conceptual clarification of different patterns of intellectual aptitudes as forces which generate possibly different ways of being creative in science. We decided that Guilford's work on the structure of intellect was the farthest advanced in discerning and separating out such intellectual factors; hence, most of the factors found in his work should be represented in any such battery. Our conclusions were primarily these: First, that one should use all the tests of divergent thinking, since they are more directly relevant to originality; next, that one should use as well nearly all the tests of convergent thinking plus selected measures from cognition and evaluation. In other words, the emphasis should be on the two aspects of thinking which seem to be most important in creative problem-solving in science -- divergent thinking and convergent thinking, with selected measures from cognition and evaluation. Then, within that general framework, there should be placed various other tests of demonstrated validity which are generally used and accepted. There would be a place for scholastic aptitude tests and advanced science tests administered at the high school level, science reading tests, the Flanagan Aptitude Classification Test, mechanical comprehension tests, and so on.

Under the domain of temperament we included a number of dimensions which we thought were relevant here and that you'd want to investigate in any case where you're attempting to find out just what the correlates of creativity are. The first of these is stability-instability. Another is impulse-expression vs. impulse-suppression. Here we had some ideas -- some of them have been stated already -- concerning how this might work in the creative personality. Still another dimension is socialization-asocialization (social responsibility, delinquency, and so on). Others are independence-conformity, energy-lethargy, extroversion-introversion, dominance-submission, complexity-simplicity, and esthetic vs. practical orientation. Assuming that these are measurable dimensions, we felt that measurements on them should be obtained, if possible, without prejudging the question of their possible relationship to creativity.

C--I was just wondering whether, if we include the aesthetic, there might not be a point in including religious orientation also -- not of a doctrinal kind, but simply a tendency to neglect or to emphasize religion, including mysticism.

C--The ecstasy of the religious is rather like the ecstasy of the creator in the moment of insight.

C--It seems to me that this is an hypothesis and not a programmatic statement and that here is an area that ought to be studied. That is, there are other value orientations, and you've named two or three of the Allport-Vernon and left out the other three. Well, now isn't the question: "Value orientation of creative people is a subject for investigation," rather than "They may be this or that."

S--Yes, I agree.

C--I think there is a certain conventionality in this report. This is not to be critical; that is just the nature of life. But I think somewhere you ought to have a summary, saying that this is the best we could do but we would encourage a variety of approaches. Despite the fact that you say you have variety, you don't really, because you say that these are the promising things. These are the best hunches, so if one doesn't use those best hunches, one is put under a kind of pressure which I think is unfortunate. I think we're doing something in the very format of the report to stultify the very thing we are trying to achieve. Maybe what I'm trying to say over and over again is how can we encourage diversity at this particular time? How can we stress divergent rather than convergent thinking at this stage of research?

Q--Do you want an afterthought saying we expect negative results on some fraction of these and you might get positive results in another area?

C--When I hear a man talking who has tests to think about, he usually wants some freedom to think about tests that haven't been created yet.

Q--How much do you think people are going to be swayed anyhow by a committee report? If somebody gets a bright idea, just because it happens to not be listed in this report, that isn't going to stop him.

C--It seems to me that what is called for is a committee on the philosophy of research on creativity, to come out with a kind of philosophical mapping of the possibilities.

S--Next, I'll discuss our thoughts on the last two areas we spoke of -- on motivation and drives, and on life history information. A very happy state of affairs soon appeared in our discussion of this; namely, there are very few specific tests in this area. So we are driven, in spite of our deep-seated proclivity for conventional response, to suggesting areas in which we believe there is a very real need for new predictors. We think these are the important variables for which one would hope to have measures in a study to predict creativity.

First, we put down inquiringness of mind; curiosity as a motive. Under this, there are measures which have been mentioned. Gough has a scale on his Differential Reaction Schedule which is called "inquiringness of mind." Another is Maier's Inventory of Academic Attitudes, which apparently has built into it some degree of expression of this kind of thing -- type of inquiringness.

Second, intellectual persistence -- the drive to carry work to completion and also the tendency to return to problems -- the phenomenon of the recurrence of problems after some years of not working on them. A person who has once tackled a difficult problem often will work along at it to a point where some degree of solution is attained, and perhaps will retain a feeling of incompletion and lack of satisfaction with this, but will defer further work until some later date and then return to it. You get the phenomenon of continual recurrence to the earliest engrossing problems.

The third thing we thought of was need for complex order, which I have already discussed in my paper. Again, I feel that the Figure Preference Art Scale is one measure of that, and there are probably others. A fourth is the well known tolerance for ambiguity. A fifth is need for recognition for achievement, considering this not in the contemporary status sense but in some feeling that there is someone some time who is going to look at that work and say "Well, this was well done." It is the sense that at some point there is going to be an audience that will recognize the worth of one's work.

A sixth is need for mastery of the problem, which is close to some of the others, but we felt it is slightly different. A seventh is need for variety. An eighth is resistance to premature closure, combined with a strong need for closure (that is, the creative person has a very strong inner need for obtaining closure, but at the same time resists making the closure prematurely).

A ninth is need for autonomy, and involved in this is perhaps the need to avoid entanglements with people which interfere with intellectual commitments. What this has to do with, largely, I think, is that persons who are intensely engaged in some sort of work on a problem will tend, sometimes quite ruthlessly, to drop out other demands, or refuse to accede to other demands in order to persist on the problem which is the most meaningful to them.

A tenth is cosmic involvement (trying to see the world as a whole and yourself in relation to the total universe of your experience). And, finally, we think there is a variable which we are naming insatiability for the activity of intellectual ordering. This is a drive for which no amount of satisfaction can lead to complete gratification (a thirst for knowledge, a thirst for new problems -- such a force that it generates a persistence in the intellectual activity long after the usual kinds of rewards which might have been thought of as motivating are no longer relevant.)

Anne Roe is going to present the material on life history information especially in regard to motivation for creative activity.

Roe--What I've tried to do is to organize (into outline form) in Table 1 the major life history areas in which items should be developed, without putting in specific items. I started with the general demographic background variable. I won't read all of them but I would like to comment on a few of them. You note that after birth place I noted size of town. Size and geographical area provide some indication of what the general cultural variables are likely to be but you may want to expand upon that. I included the occupation of parents and grandparents. The occupational level of the maternal grandfather can be a very significant factor if it is discrepant from that of the father. That is, if the mother comes from a level of society different from that in which her husband is now, you may get increased pressure on the child to attain if her original level was higher, so this can be a significant dynamic factor. The use of the occupation is obvious because it is about the best single indicator of general socio-economic status.

In family life, significant others refers to others besides the parents and siblings in the immediate family relationship -- grandparents in the family or other important figures. For child rearing practices I would suggest that there are a number of fairly well worked out questionnaires in this area. I have merely indicated some special things that may not be included in some of them but which I think are relevant here. Discipline always is. Restrictions and enforcements are. These restrictions should be broken down by age: e.g., up to six years, during elementary school years, and during high school, because these responses across ages will differ significantly. By restrictions, I mean things like geographical restrictions, how far from home the child

Table 1

Life History Areas

- I. Demographic and background variables
  - A. Of self
    - 1. Age
    - 2. Birthplace (size of town)
    - 3. Marital status
    - 4. Children
  - B. Of parents and relatives
    - 1. Education and occupation of both parents and grandparents
    - 2. Religion of parents
    - 3. Achievement of relatives
    - 4. Death, separation, divorce

- II. Family life
  - A. Birth order and siblings
  - B. Significant others
  - C. Child rearing practices, including
    - 1. Parental interaction
    - 2. Closeness of relationships
    - 3. Discipline
    - 4. Restriction and enforcement
    - 5. Social patterns of parents
    - 6. Parents reaction to exploratory destructiveness
  - D. Out-of-school activities
    - 1. Preferred activities
    - 2. Companion or gang
    - 3. Collections or hobbies with special detail on parent attitudes and personal organization and persistence
    - 4. Religion
    - 5. Dating
    - 6. Travel

- III. School history
  - A. General adjustments
  - B. Achievement
  - C. Preferences
  - D. Extra-curricular activities
  - E. Outstanding positive and negative experiences
  - F. Special accomplishments and failures

- IV. Occupational history
  - A. Choice sequence
  - B. Choice basis
  - C. Actual sequence in detail
  - D. Outstanding positive and negative experiences
  - E. Special accomplishments and failures

V. Health history
    A. Special problems
    B. Developmental patterns
    C. Discrepancies between chronological and psychological maturation

VI. Special Items
    A. Imagery
    B. Present attitudes towards parents
    C. Present attitudes towards own children
    D. Present work habits
    E. Role models available
    F. Experiences affording greatest satisfaction
    G. Experiences giving greatest distress
    H. Experiences most feared
    I. Experiences most desired

could go without keeping immediate touch, what playmates he was forbidden to have or encouraged to have, how dirty could he get, how much general destruction did his mother tolerate around the house, what time he had to be home, and whether these restrictions were enforced. By social patterns I mean the social patterns of the parents. Do they entertain at home a great deal, do they go out a great deal, or are they rather isolated? And do they encourage the child to bring his friends home at any time and that sort of thing? Parents' reactions to exploratory destructiveness -- e.g., if the child takes the clock apart, not to be destructive but because he wants to find out how it works -- does the parent distinguish between this and generally destructive behavior?

C--Sets the house on fire?

S--Sets the house on fire, or blows it up with a chemistry set. Or how do they react if he uses the best turkey platter to cut up a cat on when he is investigating.

Then out-of-school activities should also be broken up into different ages. There is a general question on preferred activities -- what did he do when he could do what he wanted to do? Did he prefer to do it with one or two close companions or did he run with the gang? What collections or hobbies did the child have? Were there any objections to these collections? This special question on parent attitudes is one aspect, but the personal organization of the hobby and the persistence in it is, I think, one of our best indicators of motivation for intellectual persistence. If the child maintained a collection over a long period of time -- not only collected stuff, whether it was birds' nests or milk bottle tops, but ordered them in a certain way and took care of them and manipulated them and persisted in this over a length of time, I consider it one of the best single predictors of what he is going to do later on.

Religion refers to whether or not the parents had religious activities and how much the child followed them; and whether he came to a break at some time in the religion of his parents and how this affected him. Dating -- I guess you understand without my going into detail on that. Travel was put in because it was mentioned that travel was rather a significant factor in Allison's work.

School history includes general adjustment, achievement, preference, extra-curricular activities, and special outstanding positive and negative experiences; what in the grades was the most interesting experience he had and what upset him the most, etc. This was a little different perhaps than special accomplishments and failures.

Occupational history includes the choice sequence and the basis for the choice so far as recalled, and then the actual sequence. In other words, we want fantasy choices and actual choices and again the outstanding positive and negative experiences and special accomplishments and failures.

In health history special problems refers to whether there were particular physical disabilities or illnesses. By developmental patterns, I mean such things as growing faster, shooting up, getting taller than the other boys, and being correspondingly weaker, as usually happens, so that he is different from the others in the group and cannot participate effectively in the usual activities of the group. The discrepancies between psychological and chronological maturation should also be included.

Then a series of special items has been listed which seem for one reason or another to be useful, but which do not seem to fit together. I have a feeling that imagery is important. The present attitudes toward parents and the present attitudes toward his own children are quite significant. The role models includes those that had been available and withdrawn and accepted and changed as far as you're able to get these. Next is the general experiences, if they did not happen to be covered already, which had afforded the greatest satisfaction and which had given the greatest distress. If the experiences which afforded greatest satisfaction tie in with satisfying intellectual curiosity this is quite a significant item on the motivational side. What things were most feared, what things were most desired -- these are sort of "catch-all" questions that may or may not be relevant. I don't know. You may think of some other areas which have not been covered.

C--There is a good chance that we will be reproducing some sample biographical items and blanks. We have displayed on the table some sets of items that we have collected and if we can obtain permission and if there's enough interest, we can reproduce them so that you can all have a kit. These items are not all directly aimed at this specific target, but they could provoke ideas for new items.

S--The phrasing of the item is going to be pretty important.

C--Is it your thinking that you should focus primarily on factual responses, or would you also include almost pseudo-biographical items.

S--If you would ask "What was your outstanding positive experience in school," you would want a specific event recorded. To convert this material to a non open-ended questionnaire might be difficult. I think that with some questions it is not worthwhile doing so, but a great many of these things can be converted into machine scorable items. Some of the items would have to be tested quite a bit to be sure you are getting the idea across.

CRITERION COMMITTEE REPORT

Reported by
Robert Lacklen, National Advisory Committee for Aeronautics
and
Lindsey R. Harmon, National Research Council

Background

S--The Criterion Committee of the 1955 University of Utah Conference worked up an outline of what it considered a suitable approach to the problem of an ultimate criterion of creativity for the research scientist. It proposed a method of step by step approximation to this ultimate criterion through a series of intermediate and substitute criteria, working back in time and conceptually until the point was reached where the variables involved would be best described as early substitute criteria on the one hand and predictors on the other. It is at this point, the committee felt, that the criterion becomes a useful one for the selection of valid predictors. It is this predictor-selection problem, and the development of a criterion for this purpose, to which the 1955 committee had addressed itself.

New developments

In approaching this question anew in 1957, the Criterion Committee first noted a number of additional ideas regarding the criterion problem, which had not explicitly entered the considerations of the earlier committee. It then addressed itself to the question of whether a series of research hypotheses could be formulated which would permit an experimental attack on the criterion problem and which would have some more nearly immediate practical applications. The relation of these immediate practical criteria to any ultimate criterion might also be attacked experimentally, it was felt, by a successive-approximation procedure or a kind of follow-up and follow-back procedure similar to that suggested in 1955.

The problem of weighting the elements of any criterion was dealt with by the 1955 committee in a generalized fashion, with an essentially cut-and-try methodology for testing the adequacy of any weighting system against an ultimately subjective criterion. The 1957 conference produced several new and somewhat more explicit approaches to the problem of measurement in the criterion field. Each of these requires description in order than an adequate experimental approach may be formulated.

Brewster Ghiselin's suggestion that the measure of a creative product should be "the extent to which it restructures our universe of understanding" is perhaps the most outstanding new formulation. Closely related is the definition by Robert Lacklen that a measure of creativity of a contribution may be made in terms of the extent of the area of science which it underlies. The more basic a contribution, the wider its effects. These two definitions may be considered as very nearly equivalent in meaning, as the incorporation of a basic contribution will require a more extensive restructuring of our universe of understanding than will a less fundamental proposition. It should be noted here that both of these definitions involve the concept that it is ideas, rather than concrete products, that are involved, and that extent of impact is to be measured in terms of the effect on the structure of science, rather than upon society directly. The exploitation of new scientific ideas in the domain of technology is another field of discourse, and the social significance of a contribution is not the measure of its importance for the present discussion. It is recognized that the two may be correlated, and perhaps highly correlated. Yet, conceptually, they are kept distinct in this report.

The committee expressly considered the quality-quantity problem in scientific creativity and the related question of the scope or diversity of the fields in which an individual makes a contribution. These are two problems which might generally be classed in the area of "weighting of criterion components" in terms of the 1955 report, but it was felt that a more explicit formulation of hypotheses relating to them was both necessary and feasible for the more practical short-range criterion problem to which the present committee addressed itself.

The separation of the various disciplines had been recognized in 1955 as necessary for securing adequate evaluation of products by people versed in each special field. The 1957 committee recognized that such separation is necessary also in dealing with predictors, as it may be found that there are elements in one field which are quite different from those in another. Initially separate analyses, with the possibility of later combinations of fields, was therefore felt to be important for attaining both elegant experimental design and practical utility.

The problems of attribution of creative scientific products had been acknowledged in 1955. The suggestion was offered this year that, in the practical working situation, it might be possible to establish the source of ideas that come out of a cooperative work group. In many cases, the administrative procedures would be such that almost all important ideas would issue as reports of one sort or another. Where this did not occur, careful inquiry of the members of a working group would usually determine the source of any research ideas of importance. As it will probably be necessary in any case to carry on practical research programs in this area within a given laboratory, one might expect work situations of sufficient homogeneity that no grave errors would develop in assignment of products (ideas) to their originators. It was felt probable that individual differences in idea productivity would be so great that errors of attribution would not profoundly affect the rank orders within a given group, even though individual errors might be fairly frequent.

It was felt that the time had arrived when some practical approaches might be made in at least some phases in the criterion question. Some of these ideas were formulated in the form of a hypothesis to be investigated and these are reported below. Other ideas, not always readily expressed as research hypotheses, but nevertheless capable of being investigated empirically, or of importance with respect to any empirical investigations, are presented in the following paragraphs.

It was felt that it should be feasible (although difficult) to construct a scale employing the Ghiselin-Lacklen formulation by any of several well-known rating scale construction procedures, and to apply such a scale to the intellectual products of the researchers. In all the comments to follow, a product is to be interpreted as an intellectual product rather than a concrete object.

The reliability of such a scale and its applicability to products of people in different disciplines and from different laboratories and to products varying in format would need to be determined. Format variations were conceived of as including patents, internal reports, lectures, published journal articles, and books.

Some specific points to be explored with regard to evaluation of such products include research suggestions made explicit in an individual's published writings or lectures, with particular attention being given to the provocativeness of the suggestions or their scope in terms of the Ghiselin-Lacklen formulation. Length of publication, particularly as regards a book vs. a brief journal note, must be carefully considered. The extent to which a researcher's material is actually published or written up vs. the amount of material he has completed but has not yet written up was felt to be important as a possible error in evaluating his creativity. Conditions surrounding publication, such as security regulations, attitude of supervision, policy of the organization, number of co-authors, and varying merit of the journals in which articles are published, would need also to be considered.

Limitations on the extent to which important ideas are recorded in a manner permitting evaluation must be considered. An example is the frequency of informal consultations between two workers that result in a new idea which cannot be adequately attributed to either worker alone.

Problems relating to the researcher's age and experience, to variations between fields, and to the operating conditions under which one works, all will require attention as factors to be controlled either experimentally or statistically in deriving criteria to be interpreted as measures of individual creativity.

Some attention and special treatment may have to be given to work that opens up a completely new field of research or which provides the avenues and stimulation that attract other researchers to move into a new field. Similarly, work that is so definitive as to close out a field of research might need special recognition and treatment.

Taking these new contributions into account, and reformulating to some extent the concepts of the 1955 Criterion Committee, a series of hypotheses is proposed, together with some sketch of experimental designs by which they might be tested. These hypotheses are as follows:

Hypothesis 1: There is a substantial relation between level of creativity exhibited by an individual research scientist and the amount of his creative productivity. Procedure for test: Assuming that an adequate scale of "level of creativity" has been set up, evaluations of creative products (ideas) will be made individually and anonymously, so that they cannot be related to the individual who produced them. Each product will be evaluated in terms of "the extent to which it restructures our universe of understanding." Products will then be assigned to their creators, and the amount and level of creative product for each individual determined. Several variables might be explored for this purpose:

a. Highest level for the individual

b. Median level for each individual's products

c. Mean level of each individual's products

d. Total number of products

e. A quality-quantity criterion score, derived as the sum of level scores for each individual's products

f. A quality-quantity score determined on the basis of equal standard-score weight for quality and quantity (i.e. insure that the distributions of the quality scores have a standard deviation equal to that of the quantity scores)

The correlational approach is suggested as a suitable statistical model for testing this hypothesis. For example, if a high correlation should be found for variables a and d, the hypothesis would be sustained. However, detailed statistical plans for exploring this question were not drawn.

Hypothesis 2: The diversity of an individual's contributions in science is related positively to the level of creativity of the products.
Procedure for test: A diversity score, in terms of the number of science fields in which contributions are made, could be added to the list of variables described under Hypothesis 1. Any of a number of schemes might be used to derive a diversity score; no explicit formulation of a scheme was suggested by the committee. The score, however derived, could be correlated with the variables listed under Hypothesis 1 to test Hypothesis 2.

Hypothesis 3: A scale of "creativity level" of products (constructed to conform to the Ghiselin-Lacklen formulation) will yield reliable results in comparison of products in differing fields, from different laboratories, and applied by people of varying disciplines and different laboratories.
Procedure for test: Assuming that a satisfactory rating scale for level has been set up, it will be applied to sets of products of laboratories involved in the experiment. The products will include those of several different disciplines, and judges will be of varying disciplines and from laboratories under different jurisdiction (e.g., government, industry, universities). The product ratings will be subjected to analysis of variance treatment to determine the amount of variance attributable to the individual raters, to disciplines of raters, to laboratories, to disciplines of products, and to the products themselves. The proportion of the variance in the final category will be the measure of the validity of the hypothesis.

Hypothesis 4: The formulations of Ghiselin and Lacklen relating to the measure of creativity of a product are positively related to a more generalized and subjective judgment of creativity independently derived.
Procedure for test: Ratings of products based on (a) the Ghiselin-Lacklen formula and

(b) on generalized "creativity" ratings on a rating scale would be obtained independently from different individuals or panels of judges. The correlation of these two independently-derived scores for a set of products would test the hypothesis. Study of discrepancy cases where evaluations were not in accord would possibly furnish greater insight into the general problem of the evaluation of creativeness.

Hypothesis 5: For evaluation of journal articles, abbreviated procedures can be developed which, although they may reduce reliability of ratings, will not appreciably affect the validity of the evaluations, corrected for attenuation.
Procedure for test: Conditions will be similar to those for Hypothesis 3, except that the journal articles will be independently evaluated by two different panels each employing four different procedures:

1. A simple count of number of titles attributable to each author.

2. An evaluation based only on titles and journal in which published.

3. An evaluation based on an abstract.

4. An evaluation based on careful study of the whole article.

Quality-quantity scores will be derived from procedures 2, 3, and 4, and all the intercorrelations of the seven resulting scores (one for procedure 1, two each for procedures 2, 3, and 4) and of a subjective panel rating will be run. The intercorrelations in this matrix will yield determinations of the reliability of the several procedures and their "validity" against the independent subjective panel judgment.

Hypothesis 6: Creative accomplishments will be recorded in some manner, and this record can be used in evaluating the creativeness of the individuals in an organization.
Procedure for test: Independent evaluations of the recorded products of all the research scientists in a given organization, and direct evaluation (by peers) of the creativeness of the same scientists, can be made. The record of products, after evaluation and attribution to the individual creator, and derivation of criterion scores such as those suggested in Hypotheses 1, 2, and 3, is also made. The pooled judgment of peers will then be correlated with the official record, and the degree of correlation will be the measure of the validity of the hypothesis. The correlation between the official record of products, and one made specifically for a criterion study (as in Hypothesis 1) will afford a second measure of the validity of Hypothesis 6.

Hypothesis 7: An evaluation of the leadership creativity of a supervisor of researchers can be derived from the productivity of those whom he supervises.
Procedure for test: A group of first-line supervisors of research people will be selected so that the conditions under which they work are roughly similar. For each of these supervisors, the following variables will be derived:

1. A quality-quantity product evaluation of the supervisor's own direct products.

2. A rating on personal research competence by: (a) peers, (b) superiors,

and (c) subordinates.

3. A rating on research leadership by each of the same three groups.

4. A "supervisory product score" derived as the sum of the quality-quantity scores for all the products of all the subordinates during the time that they were under his supervision.

By analysis of variance techniques, the proportion of the variance in the "supervisory product score" attributable to variable 1, to 2, to variables 1 and 2 together, to variable 3, and to variables 1, 2, and 3 together will be determined. It is assumed that the remaining variance unaccounted for here may be attributed to the individual differences in the competence of the researchers themselves, and to conditions of their work independent of the supervisor's research leadership.

Hypothesis 8: This is entirely parallel to Hypothesis 7 except that it refers to teachers, to their teaching ability, and to the products of their students rather than subordinates.

Other hypotheses, such as those above, but designed to cover additional aspects of the committee's work, might well be derived. The above hypotheses and proposed tests are to be considered as examples only.

REFERENCES

(Note: This bibliography is intended to be used as a continuation of that printed in the Proceedings of the 1955 Conference on the Identification of Creative Scientific Talent. Hence, items contained in the 1955 listing are not repeated here.)

1. Abrams, E. N. A comparative factor analytic study of normal and neurotic veterans, 1949. Thesis, Univer. of Michigan, Univer. Microfilm, Ann Arbor, Michigan.

2. Adkins, D. C., & Kuder, G. F. The relation of primary mental abilities to activity preferences. Psychometrika, 1940, 5, 251-262.

3. Anonymous. Getting round pegs into round holes. Amer. Engin., June 1956, 20-22.

4. Anonymous. How to lick the engineering shortage. Mgmt. Methods, July 1956.

5. Baker, John R. The Scientific Life. New York: Macmillan, 1943.

6. Barkan, Manuel, & Mooney, Ross L. Conference on Creativity; A Report to the Rockefeller Foundation. Ohio State Univer., 1953. (Mimeographed, 167 pp.)

7. Brozek, J., & Tiede, K. Reliable and questionable significance in a series of statistical tests. Psychol. Bull., 1952, 49, 339-341.

8. Calvert, J. F., Hartenberg, R. S., Kliphardt, R. A., Shelley, H. P., & Denavit, J. Developing problem-solving skills in engineering. Final Rep. Contract N7onr-45012. Evanston, Ill.: Northwestern Univer., 1953.

9. Cattell, R. B., & Drevdahl, J. E. A comparison of the personality profile (16 P. F.) of eminent researchers with that of eminent teachers and administrators and of the general population. British J. Psychol., 1955, 46, 248-261.

10. Chorness, M. H., & Nottelmann, D. H. The prediction of creativity among Air Force civilian employees. Research Bull., AFPTRC-TN-57-36. Air Force Personnel and Training Research Center, Lackland Air Force Base, Texas. March 1957.

11. Cornell, F. G., Damrin, Dora E., Saupe, J. L., & Crowder, N. A. Proficiency of Q-24 radar mechanics: III. The Tab Test -- a group test of troubleshooting proficiency. Research Bulletin, AFPTRC-TR-54-52. San Antonio, Tex.: Air Force Personnel and Training Research Center, Lackland Air Force Base, Nov. 1954.

12. Denton, J. C. & Taylor, C. W. A factor analysis of mental activities and personality tests. Psychometrika, 1956, 20, 75-81.

13. Drevdahl, J. E. An exploratory study of creativity in terms of its relationships to various personality and intellectual factors. Ph. D. Dissertation, University of Nebraska, Lincoln, Nebraska.

14. Drevdahl, J. E. Factors of importance for creativity. *J. Clin. Psychol.*, 1956, *12*, 21-26.

15. Easton, W. H. Creative thinking and how to develop it. *Mech. Engin.*, August 1946.

16. Flanagan, J. C. *Aptitude Classification Tests.* Chicago: Science Research Associates. 1954.

17. Flanagan, J. C., et al. *Critical Requirements for Research Personnel.* Pittsburgh: American Institute for Research. 1949.

18. Flanagan, J. C. The Flanagan Aptitude Classification Tests. *Personnel & Guidance J.*, 1957, *25*, 495-507.

19. Flanagan, J. C. Job Element Aptitude Classification Tests. *Personnel Psychol.*, 1954, *7*, 1-14.

20. Gordon, William J. J. Operational approach to creativity. *Harvard Business Rev.*, 1956.

21. Guilford, J. P. Creative abilities in the arts. *Psychol. Rev.*, 1957, *64*, 110-118.

22. Guilford, J. P. A revised structure of intellect. *Rep. Psychol. Lab.*, *19*, Los Angeles: Univer. Southern Calif., 1957.

23. Guilford, J. P. The structure of intellect. *Psychol. Bull.*, 1956, *53*, 267-293.

24. Guilford, J. P., & Christensen, P. R. A factor-analytic study of verbal fluency. *Rep. Psychol. Lab.*, *17*, Los Angeles: Univer. Southern Calif., 1956.

25. Guilford, J. P., Christensen, P. R., Bond, N. A., & Sutton, M. A. A factor analysis study of human interests. *Psychol. Monogr.*, 1954, *68* (whole no. 375).

26. Guilford, J. P., Christensen, P. R., Frick, J. W., & Merrifield, P. R. The relations of creative-thinking aptitudes to non-aptitude personality traits. *Rep. Psychol. Lab.*, *20*, Los Angeles: Univer. Southern Calif. , 1957.

27. Guilford, J. P., Christensen, P. R., & Wilson, R. C. Relations of creative responses to working time and instruction. *J. exp. Psychol.*, 1957, *53*, 82-88.

28. Guilford, J. P., Frick, J. W., Christensen, P. R., & Merrifield, P. R. A factor-analytic study of flexibility in thinking. *Rep. Psychol. Lab.*, *18*, Los Angeles: Univer. Southern Calif., 1957.

29. Guilford, J. P., Kettner, N. W., & Christensen, P. R. A factor-analytic study across the domains of reasoning, creativity, and evaluation. II. Administration of tests and analysis of results. Rep. Psychol. Lab., 16, Los Angeles: Univer. Southern California, 1956.

30. Guilford, J. P., Kettner, N. W., & Christensen, P. R. The nature of the general reasoning factor. Psychol. Review, 1956, 63, 169-172.

31. Guilford, J. P., Wilson, R. C., & Christensen, P. R. A factor-analytic study of creative thinking. II. Administration of tests and analysis of results. Rep. Psychol. Lab., 8, Los Angeles: Univer. Southern California, 1952.

32. Guilford, J. P., Wilson, R. C., Christensen, P. R., & Lewis, D. J. A factor-analytic study of creative thinking. I. Hypotheses and description of tests. Rep. Psychol. Lab., 4, Los Angeles: Univer. Southern California, 1951.

33. Harris, R. H. The development and validation of a test of creative ability. Dissertation Abstr., 1955, 15, 1891.

34. Harris, R. H., & Simberg, A. L. AC test of creative ability. Examiners Manual. Flint, Michigan: General Motors Corp.

35. Heath, A. Time-saving procedures for computing t-equivalents, Chicago, Ill.: Michael Reese Hospital, 1955.

36. Hills, J. R. Can we find the latent scientists? School & Society, 1957, 85, 306-308.

37. Hills, J. R. Controlled association scores and engineering success. J. Appl. Psychol., in press.

38. Hills, J. R. Factor-analyzed abilities and success in college mathematics. Educ. Psychol. Measmt., 1957, 17, 615-622.

39. Hills, J. R. Scoring a controlled-association test. Research Bull. 56-12. Princeton, N. J.: Educational Testing Service, 1956.

40. Hoggan, R. M. Productivity in research and development. Science, 1950.

41. Jacobson, B. Clusters of responses to a personality inventory which are typical of creative engineers. Unpublished manuscript, Iowa State Coll., 1956.

42. Kruskal, W. H., & Wallis, W. A. Use of ranks in one-criterion variance analysis. J. Amer. Statistical Assn. 1952, 47, 583-621.

43. Mooney, Ross L. The artist and our human need. J. Human Relations, summer issue, 1955, 9-16.

44. Mooney, Ross L. Classification of items in a preliminary listing of indices of creative behavior, Bur. of Educ. Res., Ohio State Univer., 1954. (Mimeographed, 10 pp.)

45. Mooney, Ross L. Creation, parents, and children. *Progressive Educ.*, 1953, *XXXI*, 14-17.

46. Mooney, Ross L. Cultural blocks and creative possibilities, *Educ. Leadership*, 1956, *XIII*, 273-278.

47. Mooney, Ross L. Evaluating graduate education. *Harvard Educ. Rev.*, 1955, *XXV*, 85-94.

48. Mooney, Ross L. Groundwork for creative research, *Amer. Psychologist*, 1954, *IX*, 544-48. Reprinted as Chapter XX in *The Self: Explorations in Personal Growth*, edited by Clark E. Moustakas, Harpers, New York, 1956.

49. Mooney, Ross L. Materials used to supplement a talk on cultural and emotional blocks to creative activity. *Bur. Educ. Res.*, Ohio State Univer., 1955. (Mimeographed, 6 pp.)

50. Mooney, Ross L. On meeting cultural blocks to creativity in the Army Engineer Research and Development Laboratories, *Bur. Educ. Res.*, Ohio State Univer., 1957. (Mimeographed, 30 pp.)

51. Mooney, Ross L. Perception and creation. *Bur. Educ. Res.*, Ohio State Univer., 1956. (Mimeographed, 21 pp.)

52. Mooney, Ross L. Perception and creation. Talk prepared for summer seminar in creative engineering, Massachusetts Institute of Technology, 1956.

53. Mooney, Ross L. A preliminary listing of indices of creative behavior. *Bur. Educ. Res.*, Ohio State Univer., 1954. (Mimeographed, 11 pp.)

54. Mooney, Ross L. Problems in the development of research men. *Educ. Res. Bull.*, 1951, *XXX*, 141-150.

55. Mooney, Ross L. The researcher himself. Chapter Seven in *Research for Curriculum Improvement, 1957 Yearbook*, 154-186. Washington, D. C.: Assoc. for Supervision & Curriculum Development.

56. Mooney, Ross L. Some considerations on cultivating creativity in teacher-education institutions, *Bur. Educ. Res.*, Ohio State Univer., 1954. (Mimeographed, 8 pp.)

57. Mooney, Ross L. Toward a realization of the elementary conditions of existence. *Bur. Educ. Res.*, Ohio State Univer., 1957. (Mimeographed, 13 pp.)

58. Mooney, Ross L., & Bargar, Robert. College of education faculty roundtable on esthetic experiences in the education of teachers. *Bur. Educ. Res.*, Ohio State Univer., 1957. (Mimeographed, 106 pp.)

59. Mooney, Ross L. Perception as a transaction. *Bur. Educ. Res.*, Ohio State University, 1951.

60. Oliver, J. A., & Ferguson, G. A. A factorial study of tests of rigidity. *Canad. J. Psychol.*, 1951, *5*, 49-59.

61. Olson, F. The nature of creative thinking. (Review) *Phi Delta Kappa,* 1954. Feb., 193-200.

62. Owens, W. A., Schumacher, C. F., & Clark, J. G. Tests for creativity in machine design. *Examiners Manual*. Ames, Iowa: Iowa State Coll. Res. Found., 1956.

63. Pemberton, C. L. The closure factor related to temperament. *J. Pers.,* 1952, *21*, 159-175.

64. Pepinsky, Harold B., Pepinsky, Pauline N., Pavlik, William B. Motivational factors in individual and group productivity. Vols. 1, 2, 3, & 4. Ohio State University, 1956.

65. Polder, Edward J. Bibliography on scientists and creativity. *Bur. Educ Res.* Ohio State University, 1954, (Mimeographed, 10 pp.)

66. Polya, G. *Mathematics and Plausible Reasoning*. Volumes I and II. Princeton: Princeton University Press, 1954.

67. Purdy, D. L. Creative engineering - a concept. *Personnel Admin.*, 1957, *20*, 7-13.

68. Raine, W. J., & Hills, J. R. Measuring intra-individual variability within one testing. *J. Abnorm. Soc. Psychol*., (in press.)

69. Rees, H. E. A psychology of artistic creation as evidenced in autobiographical statements of artists. New York: Bur. Publications, Teachers Coll., Columbia University, 1942, 209 pp.

70. Roe, Anne. Alcohol and creative work: painters. *Quart. J. Studies on Alcohol,* 1946. *6*, 415-467.

71. Roe, Anne. Analysis of group Rorschachs of biologists. *J. Projective Techniques*. 1949, *13*, 25-43.

72. Roe, Anne. Analysis of group Rorschachs of physical scientists. *J Projective Techniques*, 1950, *14*, 385-398.

73. Roe, Anne. Analysis of group Rorschachs of psychologists and anthropologists. *J. Projective Techniques,* 1952, *16*, 212-224.

74. Roe, Anne. Artists and their work. *J. Personality,* 1946, *15*, 1-40.

75. Roe, Anne. *The making of a scientist*. New York: Dodd, Mead & Co., 1953, (244 pp.)

76. Roe, Anne. Painting and personality. Rorschach Res. Exchange, 1946, 10, (3), 86-100.

77. Roe, Anne. The personality of artists. Educ. & Psychol. Measmt., 1946, 6, 401-408.

78. Roe, Anne. Psychological tests of research scientists. J. Consulting Psychol., 1951, 15, 492-495.

79. Roe, Anne. The psychology of occupations. New York: John Wiley & Sons, 1956.

80. Roe, Anne. Rorschach study of a group of scientists and technicians. J. Consulting Psychol., 1946, 10, 317-327.

81. Rokeach, M. I. The nature and meaning of dogmatism. Psychol. Rev., 1954, 61, 194-204.

82. Rossman, J. The psychology of the inventor. Washington, D. C.: Inventors Publ. Co., 1931.

83. Scheier, I. H., & Ferguson, G. A. Further factorial studies of tests of rigidity. Canad. J. Psychol., 1952, 6, 18-30.

84. Siegel, S. Nonparametric statistics for the behavioral sciences. New York: McGraw-Hill, 1956.

85. Smith, Downie J. F., & Owens, William A. Creative ability in machine design. Res. Rev., 1956, 18-20.

86. Snedecor, G. W. Statistical methods (4th ed.). Ames, Ia.: Iowa State Coll. Press, 1946.

87. Stein, M. I. On the roles of the industrial researcher and the problem of creativity, 1958 (in preparation).

88. Studman, L. G. Studies in experimental psychiatry: V. "w" and "f" factors in relation to traits of personality. J. Ment. Sc., 1935, 81, 107-137.

89. Taaffe, G. The relation of experimental tests of reasoning and creative thinking to research performance. Rep., Contract N6onr-23810. Los Angeles: Univer. Southern California, 1953.

90. Taylor, Calvin W. (editor) The 1955 University of Utah research conference on the identification of creative scientific talent. Salt Lake City: Univer. of Utah Press, 1956.

91. Taylor, Calvin W., Smith, William R., Ghiselin, Brewster, Sheets, Boyd V., & Cochran, John R. Communication abilities in military situations (in process of publication as technical report), WADC-TR-58-92. Pers. Lab., Wright Air Development Center, 1958.

92. Taylor, D. W. Research on problem solving and creative thinking. Final Rep., Contract N6onr-25125. Stanford, Calif.: Stanford Univer. Press, 1956.

93. Taylor, D. W. Studies of problem-solving. Final Rep., Contract Nonr 225-02. Stanford, Calif,: Stanford Univer., 1956.

94. Taylor, D. W., Berry, P.C., & Block, C. H. Does group participation when using brainstorming facilitate or inhibit creative thinking? *Admin. Sci. Quart.*, 1958, *3*. (See also: Technical Report I, Contract Nonr 609(20). New Haven: Depts. Industr. Admin. & Psychol., Yale Univer., 1957.)

95. Taylor, D. W., & Block, C. H. Should group or individual work come first on problems requiring creative thinking when equal time is devoted to each? Technical Report 2, Contract Nonr 609(20). New Haven: Depts. Industr. Admin. & Psychol., Yale Univer., 1957.

96. The nature of creative thinking. Industr. Res. Inst., 1952-53.

97. Thurstone, L. L. Creative talent. *Rep. Psychometr. Lab.*, No. 61. Chicago: Univer. Chicago Press, 1950.

98. Tolces, Tosca. Creative discipline: exploration in awareness. Portland, Maine: Bond Wheelwright Co., 1956, 115 pp.

99. Transcription of discussion on creativity in engineering fields at AC Spark Plug Division. General Motors Corporation, 1953 (Mimeographed).

100. Tuska, C. D. *Inventors and Inventions*. New York: McGraw-Hill, 1957.

101. Van Zelst, R. H., & Kerr, W. A. Some correlations of technical and scientific productivity. *J. Abnorm. Soc. Psychol.*, 1951, *46*, 470-75.

102. Vennig, George H., and Polder, Edward J. A bibliography on creativity, *Bur. Educ. Res.*, Ohio State Univer., 1954 (Mimeographed, 54 pp.).

103. Welch L., Diethelm, C., & Long, L. Measurement of hyper-associative activity during elation. *J. Psychol.*, 1946, *21*, 113-126.